THE JOURNAL OF
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April, 1955 Vol. 45, No. 8

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The American Society for Engineering Education

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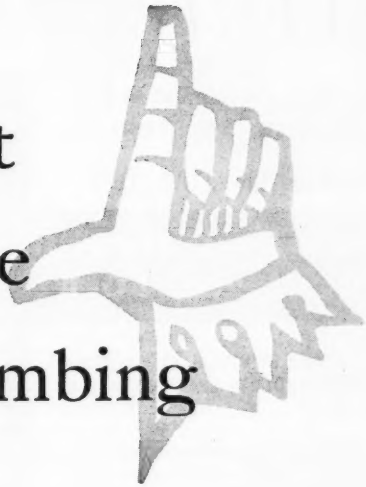

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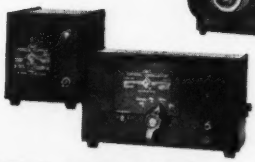
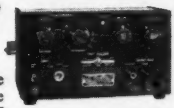

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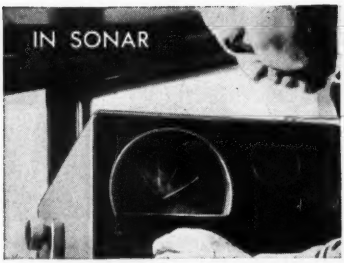

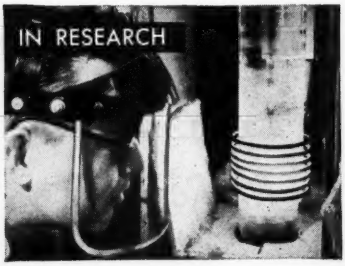

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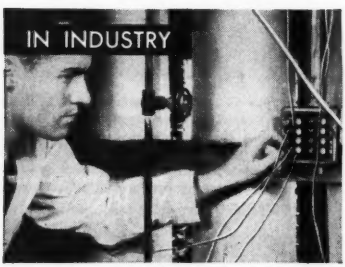

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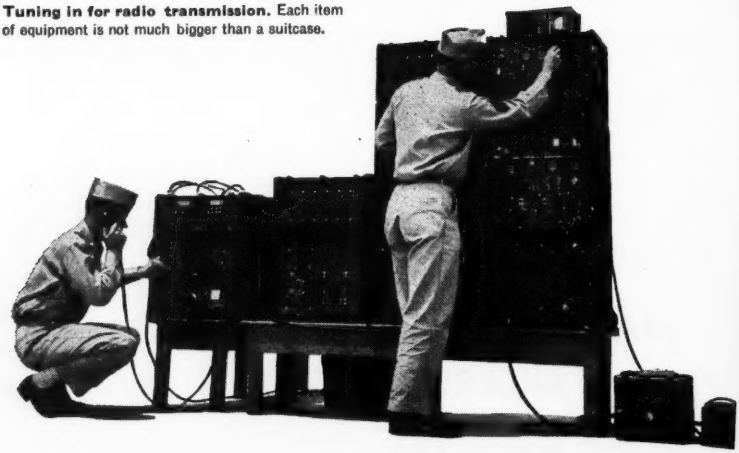

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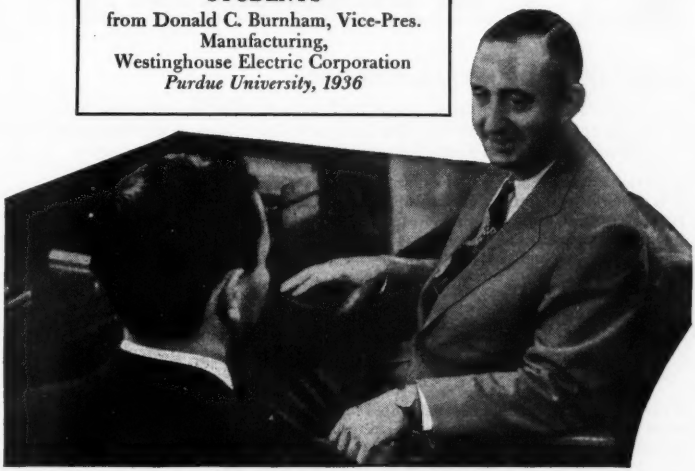

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▶ The Annual Meeting is at Penn State, State College, Pennsylvania, June 20–24, just as you have been hearing for a long while. However, you should know the institution's full name is The Pennsylvania State University and that the name of the city recently has been changed to *University Park*. So whether you are urged to go to State College or University Park, Pennsylvania, you will get to the Annual Meeting.

▶ The folks at Penn State are saying they are located in the "vacation land" portion of the state and have planned interesting events for the ladies. The Reading Room and Studio of the Hetzel Union Building will be open all week. There is a Welcoming Tea on Monday, trip to Penn's Cave followed by a Pennsylvania Dutch luncheon, a bridge luncheon at Centre Hills Country Club, a trip to nearby historic Boalsburg for their annual festival, and an illustrated lecture on the Amish in Pennsylvania.

▶ Adequate plans are also being made for the young folks. The University Nursery School will be available with experienced nursery-school teachers for children age three to six. The fee for the entire period is $3.00. See the Preliminary Program for more details.

For children six to eleven daily programs of games, crafts, picnics, swimming, etc., are planned.

The teen-agers also have their special events—get acquainted party, all day picnic and swimming at Whipples Dam, dancing, games, roller skating and, lastly, a farewell party at which tournament prizes will be awarded.

▶ The closed conference on Thermodynamics, jointly sponsored by ASEE and NSF, was held at Purdue University on February 28 and March 1. Almost all of the discussions pertained to the open *Conference on Thermodynamics in Engineering Education* to be held at Penn State on June 27–29. It was agreed that the Conference should be aimed at young teachers of engineering thermodynamics and the program developed centers around some of the aspects of thermodynamics which are having an impact on engineering and engineering education. Some of the speakers who already have accepted are Matt Souders, G. A. Hawkins, Newman Hall, M. Zemanski, Samuel Glasstone and Henry Eyring. For detailed information write to W. E. Ranz, Associate Professor of Engineering Research, The Pennsylvania State University. Registration is limited to 125 persons.

▶ The joint meeting of the Relations with Industry Division and the Iowa Engineering Society at Des Moines, Iowa, on March 1 and 2, was a rousing success. Over 500 attended the well-planned two-day program. The Advisory Committee and the Executive Committee of the Division each held a meeting and on the second day the joint session program theme was "Current Problems Facing the Engineering Profession." Professionalism, unionism, and unity were discussed. At the Annual Banquet our President, N. W. Dougherty, spoke enthusiastically and interestingly on "Today Is Not Midway Between Yesterday and Tomorrow." Even the ladies were enthusiastic! The President hasn't announced the title of his annual address, but if the RWI speech was a sample, be sure to plan on hearing President Dougherty at Tuesday's General Session of the Annual Meeting.

► The English Division has mailed out its notice and program for its Summer School at Penn State, June 24 and 25. They hope to promote a fruitful exchange of facts and views between the English and engineering members of faculties and between administrators and classroom teachers. The program speakers are R. W. VanHouten, President, Newark College of Engineering; J. L. Vaughan, University of Virginia; W. D. McIlvaine, Jr., University of Alabama; Douglas Washburn, Rensselaer Polytechnic Institute; Frank Kerekes, Michigan College of Mining and Technology; W. G. Crouch, University of Pittsburgh.

► *Here is how to get to Penn State.*

By highway, the intersection of highway routes US 322 and Penna. 45.

By bus, the Greyhound Bus Lines from Pittsburgh, Harrisburg or Scranton and the Edwards Bus Line from Elmira, New York (by way of Williamsport, Penna.) and from Cleveland, Ohio.

By train, the Pennsylvania Railroad: from the west to Altoona, Penna., and then by Greyhound Bus Lines (42 miles); from the east to Lewistown, Penna., and then the Boalsburg Bus Line (30 miles). To avoid excessive delay between train arrival and bus departure, schedule arrival at Lewistown or Altoona to coincide with the bus schedule.

By air, the Allegheny Air Lines from Pittsburgh and Newark to Mashannon airport and then a taxi (25 miles) to State College (University Park).

► Mimeographed copies of the Preliminary Program for the Annual Meeting were mailed on March 4, to all chairmen responsible for programming. As soon as the corrections and additions are received a copy goes to Lancaster Press. Then, as soon as printed, the programs are mailed to all of you by Lancaster Press; the registration, housing and special events cards will be enclosed with the programs.

► For information on Summer Schools to be held at Penn State write to:

Chemical Engineering Teachers
(June 27–July 2)

Dr. K. H. Kobe
Chemical Engineering Department
University of Texas
Austin 12, Texas

Thermodynamics Conference
(June 27–29)

Dr. W. E. Ranz
Associate Professor of Engineering Research
The Pennsylvania State University
University Park, Penna.

English
(June 24 and 25)

Dr. G. J. Christensen
Department of English
Lehigh University
Bethlehem, Penna.

► The Constitution of the Society provides for the election of the President, two Vice Presidents and Treasurer at each annual meeting by ballot of the individual membership present. The Nominating Committee consists of the three Junior Past Presidents and the General Council members elected by Sections and Divisions whose terms expire this year. Members of the Society are requested to submit names to be considered to the Secretary by April 20. The names then will be submitted to all members of the Nominating Committee.

The Vice President to be elected this year, for two years, is the Vice President in charge of Instructional Division Activities. The Second Vice President to be elected is the chairman of ECAC, who is elected to that office by the ECAC membership and automatically becomes a Vice President of the Society. A nomination blank may be found on page 477 of the January issue of the *Journal.*

W. LEIGHTON COLLINS
Secretary

Looking Ahead

By ARTHUR BRONWELL

President, Worcester Polytechnic Institute and Past Secretary of ASEE

In recent years the ASEE has undertaken numerous projects, cutting across all of engineering education, which are destined to have far-reaching influence upon the future of engineering education. These achievements are a high tribute to the enthusiasm and devoted service of many hundreds of educational leaders who have participated in the work of the Councils, Divisions, Committees, Sections and Branches of the Society. Through their efforts there has been stimulated a vigorous and constructive outlook toward engineering education which has permeated practically every engineering college of the country. Attitudes of complacency and self-satisfaction with the status quo have been supplanted by a spirit of challenge and inquiry, which penetrates to the very foundations of engineering education.

Engineering education has always been in transition. In the past,, we have seen how broad areas of engineering practice have grown from toddling infancy to giant industries in a comparatively short period of time. Not many years ago, such fields as aeronautics, electronics, chemical engineering, metallurgy, and engineering mechanics were the barbaric renegades trying to get faint recognition in the engineering curricula. Today they have earned distinctive places in the curricula and have not only contributed to the rapid development of their own professional fields, but they have also illuminated the more traditional fields with new fundamental concepts and new methods of analysis.

Today the frontiers of science and engineering are advancing at a more rapid pace than at any time in history. This geometrical growth of knowledge is continuing to open up whole new domains of fundamental knowledge which will revolutionize engineering practice of tomorrow just as assuredly as the growth of knowledge over the past quarter of a century has revolutionized engineering practice of today. This growth of knowledge presents vital challenges to engineering education. The new developments must constantly be critically examined and assessed as to their importance. When engineering education fails to be responsive to the advancing needs of the times, then our education and our industry will be well along the road to stagnation.

The ASEE project on Evaluation of Engineering Education, under the able leadership of Dean Linton Grinter, will present its final report at the Annual Meeting in June. This project, which enlisted the active participation of committees in over 120 engineering colleges throughout the country, has stimulated a vigorous and penetrating re-examination of all phases of engineering education. It has pointed the way toward a highly successful type of cooperation between faculty members in engineering colleges and ASEE committees.

The Humanistic-Social Research Project, under the direction of Dr. George Gullette, has already made substantial gains during its first year of operation. Its field committees are investigating educational programs in engineering colleges throughout the country. The visitation committees are seeking those programs which show fresh and imaginative

approaches and which hold promise of making substantial contributions to the teaching of the humanities and social sciences. This evidence will be reviewed by a committee of ASEE under the Chairmanship of Dr. Edwin Burdell and recommendations will be drawn up for improvement of education in this important area of the curriculum. The visitations of the field committees have provided a constructive influence in compelling engineering colleges to assess their own programs in these areas. The final report of the Committee will probably be presented in June 1956.

The Committee on Ethics has published in the Journal its preliminary report, recommending means of inculcating ethical concepts in our educational programs. The Committee's Chairman, Dean Clement Freund, is now working effectively with administrative officers in engineering colleges in an endeavor to get much needed recognition for this area of educational responsibility.

A proposal has just been drawn up for a project to investigate some current problems and policies relating to graduate study. The growing importance of graduate study and the many divergent viewpoints on complex problems in this area of engineering education serve to emphasize the significance of this project. It is hoped that the project, to be conducted by the Graduate Studies Division, can get under way with adequate financing this year.

Several years ago the Society completed two highly significant reports. One was on Improvement of Teaching and the other a Graduate Manual, dealing with the objectives and policies of graduate study. Both reports, prepared under the Chairmanship of Dr. Grinter, have been in heavy demand and have received high acclaim from the Society membership.

What Are The Challenges Ahead?

The foregoing studies have provided critical analyses in the dominant areas of engineering education. But what are the challenges which lie ahead? First there is the essential problem of carrying forward the study on Evaluation of Engineering Education into the individual curricular areas. The central committee of the Society could only define the broad objectives of the study—it could not make detailed investigations into each of the curricular areas. This is the problem which challenges the Divisions of the Society. It is their responsibility to project ahead with bold and imaginative thought to analyze the various alternatives to the present curricular structure and present their recommendations for constructive experimentation along soundly-conceived lines.

Second, it seems highly desirable to bring the reports of the various projects together into a bound volume, representing the current thinking on engineering education. Funds for such a project could undoubtedly be obtained from industry or from one or more foundations. Such a volume would contain the reports on Improvement of Teaching, Evaluation of Engineering Education, the Humanistic-Social project, the Graduate Studies project, the Graduate Manual and Ethics. It might also include individual reports prepared by the Divisions of the Society respecting their curricular areas. Such a composite volume would be of inestimable value to engineering educators in the years ahead.

Other significant areas of ASEE operation in recent years have included preparation of a bulletin on teaching aids, the inauguration of a Summer Institutes program and the expansion of the ASEE Summer School program.

The Teaching Aids bulletin, just completed, lists the best 290 teaching aids out of 5000 which were reviewed by Committees. This bulletin will be exceedingly helpful to engineering teachers in selecting the most effective teaching aids for engineering courses. The Committee, under the Chairmanship of Professor Carl Muhlenbruch, reviewed teaching aids

in five of the curricular areas. This project might well be extended into other curricular areas in the years ahead.

The Summer Institute program, inaugurated last year, brings together leading educational and research authorities for conferences in specific areas where there is promise of making substantial progress in engineering education. Last year's Summer Institutes dealt with Solid State Physics and Nuclear Engineering, two areas which are already making substantial inroads into engineering practice. Two additional Summer Institutes, one on Thermodynamics and another on Advanced Mathematics in Engineering, will seek out methods of unifying subject matter which is now presented from entirely different viewpoints in different curricular fields. The proceedings of these conferences will be published to disseminate the information as widely as possible. Such conferences, where leading authorities in a given field tackle a specific problem of great significance to education, can effect substantial progress in a comparatively short period of time, as compared with the slow trial-and-error method of the past.

The Summer School program has been greatly expanded during the past five years. Last year there were five Summer Schools with an attendance exceeding 450. This Summer School program has been an invigorating and dynamic influence in keeping engineering education moving ahead in response to the challenges of the times.

One of the most encouraging developments in ASEE in recent years has been the spontaneous growth of the Young Engineering Teachers movement. The YET's have developed their own activities and expanded their numbers with great vigor and enthusiasm. Active participation of young engineering teachers in ASEE affairs broadens their perspective on engineering education and improves their teaching competence. It enables them to become acquainted with their colleagues in other colleges and thus provides that vital stimulation which increases their interest in engineering education.

A recent analysis of ASEE membership records indicates that approximately 20% of the Society members are below 36 years of age. This is a truly remarkable tribute to the enthusiastic promotion which the YET's have given their movement. With further encouragement and ample opportunities to develop their own activities, this movement can grow into very substantial proportions in the years immediately ahead. It is one of the most promising developments of ASEE.

Another highly encouraging development has been the growth of relationships between the ASEE and industries throughout the country. Under the imaginative leadership of Jesse McKeon, over 120 large companies have been added to the ASEE Associate Institutional membership roles. The Division of Relations With Industry has always had a vigorous and constructive program dealing with relationships between industry and engineering colleges. This relationship is of growing importance in view of industry's desire to provide financial assistance to engineering colleges. The Associate Institutional Membership program should be promoted vigorously in the years ahead. It can yield very substantial returns, both to engineering education and to industry.

The activities of ECRC and ECAC in their respective areas of operations, dealing with research and administrative policies of engineering colleges as well as with their relationships with industry and government, have provided a valuable service to the colleges. The publication of the Directory of Research, listing research projects in engineering colleges throughout the country; the studies on the supply and demand of engineering manpower; the studies of ROTC problems; and the many other helpful services of these Councils have been exceedingly valuable to administrators of engineering colleges.

It has been gratifying to know that the principal engineering societies, the engineering profession and industry have all been solidly behind ASEE during this rising tide of ASEE activities. The contributions of $12,000 from the constituent societies of ECPD and the Engineering foundation and of $20,000 from the General Electric Company have been of inestimable value in the project on Evaluation of Engineering Education. The Carnegie Corporation's grant of $30,000 for the Humanistic-Social Project, the National Science Foundation's grants of $15,500 for the Summer Institutes, and the industrial grants for the Teaching Aids program and other ASEE projects all attest to the constructive support which the Society has been privileged to receive. Our experience has shown that industry and philanthropic foundations stand ready and willing to provide financial assistance for well-conceived projects which the Society might desire to undertake.

Unfinished Business

There is one matter of unfinished business which I would urge that the General Council take up at its meeting this June. It has been repeatedly pointed out that the Executive Boards of the Society have for a number of years consisted exclusively of engineering deans (except for the Treasurer and Secretary). The reason why deans are selected rather than college professors is quite evident. Deans are better known and usually have had broader administrative experience than college professors.

But I think that the request that a procedure be established to assure that at least one member of the Executive Board (other than the Treasurer or Secretary) comes from professorial ranks, is an entirely valid criticism. This can be achieved in either one of two ways. One procedure would be to compel the Nominating Committee to maintain at least one professor on the Board. This is probably the simplest solution, but I think that it is a highly undesirable one for reasons which I shall try to set forth.

Each year two new vice presidents are added to the Executive Board, one being selected by the Nominating Committee and the other by either the ECRC or ECAC. On the average one of these two vice presidents will eventually become President of the Society. Now I think that it is exceedingly important that the Nominating Committee have an ample pool of talent to draw from in selecting the President. For the most part, they will probably want to select a dean or other administrative officer for President because of his administrative experience. It seems highly undesirable, therefore, to erect barriers which will deliberately block the way of deans getting to the Executive Board.

There is another approach which I believe is a more satisfactory solution to the problem. This would be to create a new position on the Executive Board, to be open only to a person of professorial rank. This person would be elected by the General Council from among their own ranks.

From an organizational viewpoint, there is a very valid reason for creating a new post on the Executive Board. At present the Vice President in charge of Divisions and Committees has jurisdiction over about 35 different Divisions and Committees of the Society. During my eight years as Secretary, no vice president has ever attempted to maintain consistent contact with more than seven or eight of these units. It is a generally accepted principle in organization that no one administrator should have more than about six or seven people reporting to him. While this principle might not apply in its entirety to an organization such as ASEE, it is clearly beyond reason to expect a vice president to maintain active and helpful contact with 35 different units. The fact that no vice president in the past eight years has done this bears out the inadequacy of the present organization.

Briefly, the proposal then is as follows. The General Council at its meeting in June would establish a new post on the Executive Board, with appropriate title and duties as specified by the Council. The Council would elect from among its own constituency a person of professorial rank to fill this post. The term of office would be two years, the same as that of a Vice President. All of this can be accomplished without a Constitutional amendment. At some convenient time in the future, the Constitution could be amended to give this post the title of Vice President and to specify in the Constitution the duties associated with the position. The foregoing procedure would provide a helpful period of experimentation before amending the Constitution.

During the past eight years, the Society has faced serious financial problems. A vigorous membership campaign doubled the Society membership and a campaign to expand advertising in the *Journal* substantially increased revenue from this source. The Associate Institutional membership campaign also added additional revenue. But inflationary costs in the post-war period and the expanded services of ASEE have resulted in continued financial problems. The modest increase in dues voted by the Society membership last year has solved the financial problems and it now seems evident that the Society has adequate finances for a high level of achievement.

In recent years, the Society has taken an active role in affairs of the Engineers' Joint Council, ECPD, the American Council on Education and other organizations which represent the collective efforts of the engineering and educational professions. Many of the constructive programs of these organizations have been initiated by our ASEE representatives. Dean Thorndike Saville, the ASEE representative to the Engineers Joint Council, is in his second year as its President. It is exceedingly important that ASEE cooperate fully with other major engineering societies in these joint endeavors which are becoming so important to the engineering profession.

A Word of Appreciation

It has been a great privilege and pleasure to have had the opportunity to serve as Secretary of ASEE during the past eight years. It has been a period of rising crescendo in ASEE activities —of new challenges and opportunities. Through the development of plans of mutual participation, the attention of faculty members in engineering colleges throughout the country has been focused upon ASEE activities and we have received great help and encouragement from them. It has been particularly rewarding to have had the privilege of working with the officers of the Society. Their enthusiastic support of the Society's work and tireless devotion to duty have always been a source of great encouragement.

Although the principal projects of the Society are of necessity the focal points of attention, it is in the Councils, Divisions, Committees, Sections and Branches of the Society, providing as they do a national forum for the discussion of the diverse problems on engineering education, that new ideas are brought to focus and trends established. The forward-looking programs of these groups within the Society have done much to keep engineering education moving abreast of the needs of the profession. I should like to take this opportunity to add my expression of personal gratitude for the excellent cooperation and constructive help which we have received from the officers of these groups.

Also, I wish to express my deep gratitude to the members of the office staff, particularly to the office Executive Secretary, Marion Strohm, and to the Assistant Secretary and Editor of the *Journal,* Professor Watson, for their years of devoted service. The ASEE headquarters has been seriously understaffed until recently, when the dues amendment made it pos-

sible to bring the secretarial staff up to a reasonable level. The faithful and devoted service of our headquarters staff, often operating under trying conditions and heavy overloads, has been a constant source of confidence and inspiration to me.

The Society is extremely fortunate in its choice of Professor Collins as its new Secretary. He is an educator of considerable stature and has taken active part in many ASEE affairs. At the time of his election as Secretary, he was a member of the General Council. May I urge you to give him the same enthusiastic support and wholehearted cooperation which we have enjoyed during the past eight years.

Centennial Engineering Symposium

Michigan State College, the first of the land-grant colleges in the United States, commemorates its Centennial this year. For its contribution to the Centennial program the School of Engineering is sponsoring on May 12 and 13, 1955, the sixth of a series of ten academic symposia as a means of focusing attention on automation, one of the most important developments in its entire field of engineering. This Centennial Engineering Symposium is planned to be one of broad, national interest with programs built around a series of general sessions of interest to all branches of engineering and a concurrent series of meetings sponsored by the seven individual departments of the school.

The general symposium theme will be "Automation—Engineering for Tomorrow." This latest and powerful tool of the engineer, which is having an increasing impact on the lives of all Americans, will be surveyed from its lowly beginnings through its present accelerating and far-ranging development to its unlimited future potentialities in the decades to come. General sessions held in the morning of May 13 will be devoted to presentation of two topics for discussion, "Automation—To Date" and "Development of Automatic Production Facilities." Important luncheon and banquet speakers will be Dr. W. R. G. Baker, Vice-President of the General Electric Company, and Dr. Eric A. Walker, Dean of Engineering at Pennsylvania State University. Dr. Baker will speak on "Automation as an Engineer Sees It," developing his subject from the technical point of view. Dean Walker will discuss "Automation—A Look into the Future" from the philosophical or sociological point of view.

In the afternoon of May 13 each department of the School of Engineering, including those departments holding a more comprehensive two-day meeting, will sponsor its own concurrent series of meetings on those special themes of automation which will be of considerable interest to men in its particular field. These meetings will present as speakers many well known designers and engineers in widely diversified fields. Talks, discussions and panel sessions will be conducted by these leading authorities. Participation by representatives of national and state professional associations, societies and manufacturing groups is assured.

Report of the Joint Committee of the American Society for Engineering Education and the Mathematical Association of America on Engineering Mathematics

This Committee was appointed in the fall of 1953 and charged with:

1. Consideration of how mathematics can be taught in the most effective way for engineers;
2. Acting as liaison between ASEE and the MAA;
3. Keeping in close contact with the MAA Committee on the undergraduate mathematical program under the Chairmanship of W. L. Duren.

The matter of liaison and of keeping in contact with Duren's committee has been effected in the following ways. The first meeting of the Committee was in Baltimore on December 30, 1953 in conjunction with the annual meeting of the MAA. The second meeting of the Committee took place in Urbana on June 17, 1954 at the annual meeting of the ASEE. The MAA Committee on the Undergraduate Program was represented at our first meeting by W. L. Duren and at the second by G. B. Price. At the invitation of R. S. Burington, Chairman of the Mathematics Division of the ASEE, Price also presented to the Division a report on current efforts to revise the undergraduate program in mathematics.

The liaison between the MAA and the ASEE is probably best maintained through the Mathematics Division of the ASEE. Mathematicians engaged in teaching engineers should be encouraged to join and to support the activities of both the ASEE and the MAA. Continued publicity about the activities of the Mathematics Division of the ASEE in the *Monthly* should be encouraged.

Mathematics for Engineers

The Committee has directed its attention to the following three questions in this connection.

1. What mathematics should be taught?
2. Who should teach it?
3. How should it be taught?

What Mathematics should be taught to engineering students? This question is the subject of study and debate from many sides.

The ASEE's Committee on Evaluation of Engineering Education in its Interim Report of June 15, 1954 (p. 10) states: "At the undergraduate level, competence in the theory and use of simple ordinary differential equations and their application to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum. For students whose interests will be centered in research, development, or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary."

The MAA's Committee on the Undergraduate Mathematics program has endeavored to formulate a first year mathematics course which would "try to incorporate into collegiate mathematical teaching the valuable results of modern researches in mathematics and logic and to eliminate that which is unnecessary or

faulty." While they have in mind a program for *all* students who study mathematics in college, they are thoroughly aware of the fact that "the revision must concentrate upon the needs of the vast majority ('95 percent') of students who take mathematics to increase their powers for solving problems and grasping the ideas of science. Thus the approach to mathematics at this stage (i.e., during the first two years of college) shall be *operational* rather than merely *appreciative*." They are experimenting with, and currently engaged in writing text materials for, a basic three-hour course for all students who take mathematics for the first year. In the first semester this would take up: graphs; functions; limits; introductory calculus based on polynomials, exponentials, and logarithms. The material in the second semester would include: sets, mathematical language, groups, combinatorics, distributions, approximate sums, probability. The basic course would be supplemented for engineering and physical science students with a two-hour course as follows:

First semester

Numerical trigonometry, graphical analysis, Newton's methods, numerical integration, tables of logarithms and exponential functions, slide rule, log and semilog paper, rate problems.

Second semester

Worded problems, binary representation, computing machines, centroids and moments of inertia, averages, precision in measure and computation, finite differences, tables of normal probability, density, sampling.

For engineering students, this would be continued in the second year into a course in calculus and analytic geometry with geometric and mechanical applications using vector methods, which would also include linear differential equations with constant coefficients. The program has been tried, with success, at Tulane.

There are other experimental mathematics programs being tried at the University of Washington, Haverford College, Carleton College, The Illinois Institute of Technology, Brown University, Yale, and no doubt at many other institutions.

High School Preparation

So far as the undergraduate curriculum in engineering is concerned, the crucial question seems to be "how much useful mathematics can be taught to the engineers in the time now allotted to mathematics in the undergraduate curriculum?" The answer to this question obviously depends upon the previous mathematical preparation of the entering freshmen. Where this preparation is meager, it is now customary for the students to take college algebra, trigonometry, and analytic geometry in the freshman year and to follow this with a course in calculus in the sophomore year. Where the high school preparation includes trigonometry as well as a strong background in algebra, it is possible to give a combined course in calculus and analytic geometry beginning in the freshman year.

But not all entering freshmen engineering students will have had strong preparation in high school mathematics. There is reason to hope that significant improvements can be made in our methods of taking care of those students. Williams College has been successful in taking students without trigonometry directly into the unified calculus, analytic geometry, and differential equations course and to develop the necessary analytic trigonometry as it is needed in the calculus. The universal freshman program envisioned by the MAA Committee on the Undergraduate Program will presuppose only one year of high school algebra and one year of geometry. A program in mathematics and physics was devised at Lafayette College for students enrolled in the preinduction program sponsored by the Ford Foundation. Most of these men entered college after two years of high

school. They had studied neither physics nor trigonometry and their mathematical background was primarily limited to one year of algebra and to one year of plane geometry. The two year program at Lafayette included the essential parts of trigonometry, analytic geometry, calculus, and differential equations. Experiments along these lines while not conclusive do at least suggest the possibility of bypassing some of the traditional prerequisites for the calculus with a resulting acceleration and expansion of the useful mathematics that can be included in the normal engineering curriculum. However, some serious questions have been raised in connection with these experimental programs. The major items of concern seem to be:

1. that the existence of the experimental programs, with the low level of mathematical pre-requisites for some of them, may result in a further weakening of the high school mathematics preparation of future engineers and scientists. It is taken as axiomatic that high school students will not learn as much mathematics in two years as they would in four. In the face of increasing demands for mathematical competence, the colleges and universities (so the argument goes) should, if anything, be upgrading their entrance requirements in mathematics for students in engineering and the physical sciences. And the University of Illinois, for one, seems to be moving in this direction.
2. that the experimental courses may attempt to survey so many topics that they will attempt to teach "a little about everything and not much about anything." This may be an exaggerated fear, but it nevertheless exists.
3. that "by far and away the largest portion of engineers get along on and *use* a fair amount of the elements of algebra, plane, solid, and analytic geometry, trigonometry in particular, plus the fundamental concepts of the calculus and copious use of handbooks and tables. Moreover, whatever the shortcomings of the traditional first year mathematics courses in engineering may be, they have at least made a serious attempt to meet the student where his knowledge left off and usually provide time for review and filling in gaps."

This Committee has not had the opportunity to debate the issues raised here. Accordingly, we make no recommendation either for or against any of the experimental programs now under discussion. We do, however, endorse experimentation as such. Moreover, we feel that the prospect for curriculum improvement is enhanced by a lively and serious debate of these issues.

We also wish to call attention to an experiment of a somewhat different nature, designed to stimulate gifted students to make more progress in mathematics at an early age. The Ford Foundation through its Fund for the Advancement of Education has recently sponsored a study called "The School and College Study of Admission with Advanced Standing." The Mathematics Committee of that Study proposed a program in mathematics for the more able students which would include a strong introduction to differential and integral calculus in the *twelfth grade*. And, in a similar vein, we wish to call attention to a recent talk by R. S. Burington on "Mathematics for Our Time," reported in the *Mathematics Teacher*, vol. XLVII, No. 5, pp. 295–298, May 1954.

What conclusions, then, has this Committee reached in answer to the question "What mathematics should be taught to engineers"? We wrote personal letters to about forty mathematicians, scientists, and engineers soliciting their comments and advice on the question of what mathematics should be taught to engineers, and how it could be taught most effectively.

From the replies received we deduced that:

a. There was a consensus of opinion that all engineers would benefit by studying mathematics through at least the elementary course in ordinary differential equations.

   On the question of specific course content we are not prepared to take a stand either for or against the program proposed by the MAA Committee, largely because it is still in the experimental stage and because of certain doubts stated above.

b. Statistics and probability deserve more attention than they now receive.

   It is not at all obvious how this is to be managed within the present time limitations. One possible solution to the problem has been suggested by the MAA Committee on undergraduate curriculum. This problem deserves further study.

c. It would be highly desirable to provide the opportunity for students to take further electives in mathematics; for example advanced calculus, complex variables, numerical analysis, matrix algebra, and so on.

Who should teach mathematics to engineers? There is, of course, the possibility of a dichotomy with some people answering "the engineering staff, in order to increase motivation" and with others answering "the mathematics staff because of their deeper insight into the logical structure of the subject." In his talk at Urbana, L. W. Cohen referred to mathematics as a language. In order to learn to use this language effectively engineers need teachers who know the language thoroughly and know how to use it. In this connection we quote from the interim report of the Committee on Evaluation of Engineering Education of June 15, 1954: "A minimum level of performance in mathematics should be established whether it be obtained in required mathematics or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the students' knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency, and should be taught by staff members competent to do so."

We are in complete agreement that, in these days when some engineers need far more mathematics than the minimum now required, it is important that mathematics be taught by mathematicians who by their inspiration and enthusiasm can stimulate an interest in mathematics per se. Unfortunately, however, the impression exists that some engineering students are taught by mathematicians who have little or no appreciation for the interests and needs of the engineers. We believe that those mathematicians who are responsible for curriculum planning should consult with their engineering colleagues from time to time to try to determine the engineers' current and anticipated needs in mathematics. Then they should try to meet those needs by providing appropriate courses taught by competent, sympathetic teachers.

One experiment which has been tried, and which appears to be worth wider consideration, is for the mathematics department to invite a member of the engineering staff to teach one or more regular mathematics courses. This gives him a chance to become familiar with the structure and timing of the mathematics course, and also puts him in an excellent position to make criticisms and offer suggestions on the course from the point of view of an engineer. This might also be done on a reciprocal basis with a member of the mathematics staff teaching one of the engineering sciences in order to become familiar with the applications of mathematics in it. One member of our Committee has reported that he took part in such an experiment at the University of Illinois and found the experience valu-

able, particularly the discussions among these involved in the exchange teaching. This sort of exchange arrangement would be one way of helping a teacher to avoid getting into a rut. Other ways include: individual or group research projects, consulting on mathematics problems arising in industry or governmental laboratories, sabbatical leaves, and so on.

There are two aspects of motivation that bear further mention. On the one hand, mathematics should continually draw upon the physical and engineering sciences for illustrative problems. But, of equal or perhaps greater importance is the fact that motivation is tremendously enhanced if liberal use is made of mathematical techniques in physics and the engineering sciences, both in the first two years and in the later years. We quote again from the interim report previously cited (p. 11): "In the engineering sciences, full use should be made of the prerequisite mathematics, physics, and chemistry, recognizing that repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of these engineering sciences with an appropriate mathematical understanding."

How shall mathematics be taught to engineering students? These students are interested in mathematics as a tool. The majority of them are not content to study mathematics for its own sake. They usually can be induced to become interested in "why" a technique works, but only after they are convinced that: (a) it is a useful technique, and (b) they understand how to apply it. Teachers recognize this fact by using a large amount of problem material. In this connection, we should like to call attention to the collection of "Engineering Problems Illustrating Mathematics," prepared by a committee of the ASEE under the chairmanship of John W. Cell, and published by the McGraw-Hill Book Company in 1943. These problems are divided into categories illustrating the mathematics usually covered in college algebra, trigonometry, analytic geometry, and differential and integral calculus. It has been suggested that more material of this kind would be helpful. In particular, more examples where the emphasis is on the analysis of the problem and the methods for setting it up in mathematical form, would be desirable. A fund of such problems requiring statistical techniques would be particularly welcomed by some teachers. Our deliberations and the replies to our inquiries have indicated needs for:

a. More emphasis on numerical methods.
b. More emphasis on graphical methods.
c. More emphasis on fundamental concepts.
d. More emphasis on translation from physical problems to mathematical problems, and on the interpretation of the results of the solution of the mathematical problems in terms of the given physical problems.
e. More use of mathematics in junior and senior engineering courses.

Much has been published on the question of improvement of teaching methods. The Committee feels it is appropriate to list here, for convenient reference, the following books and articles which are related to the work of the Committee:

BOOKS AND ARTICLES RELEVANT TO THE WORK OF THE COMMITTEE

J. W. Cell, "Engineering Problems Illustrating Mathematics," McGraw-Hill (1943).

"Effective Teaching," McGraw-Hill (1950) (Fred C. Morris, Editor).

Report of the SubCommittee on Minimum Essentials in Mathematics for Engineering Instruction—California Committee for the Study of Education.

Report of the Committee on Adequacy and Standards of Engineering Education, *J. of Engineering Education*, vol. 42, No. 5 (1952), pp. 249–254.

Proceedings of the ASEE.

Vol. 39	1931–32	pp. 299–310
42	1934–35	149–152, 292–296
45	1937–38	122–131, 190–194, 548–558
46	1938–39	716–724
47	1939–40	394–401, 699–703
49	1941–42	57–66 , 346–352
50	1942–43	432–437
51	1943–44	664–668
52	1944–45	407–413
54	1946–47	330–335, 531–535, 536–539, 641–652
55	1947–48	175–180, 300–307, 308–312, 358–365, 366–373
58	1950–51	308–310
59	1951–52	170–172
60	1952–53	33–46 , 136–144, 472–475

Conclusion

One imagines that the question of "how to teach (anything)" most effectively confronts every conscientious teacher almost constantly. One also feels that the question of *motivation* on the part of the teacher is at least as important as it is for his students. If he feels that *what* he is teaching is interesting, important, esthetic, and useful—then his enthusiasm will almost certainly stimulate his students to *learn*. But no teacher can long maintain a fictitious enthusiasm for subject matter which, to him, is dull, trivial, non-esthetic, and largely useless. It is for this reason that the committee chose to include a consideration of *what* mathematics to teach as well as *how* to teach it. We do not propose any definite answers to either question. But we have pointed out some experiments which seem, to us, to be significant. In doing so, we hope not only to recognize and encourage those who are conducting these experiments, but also to stimulate others to devise their own or try some of the existing ones.

Recommendations

We recommend the following to the ASEE and MAA and their respective members involved in the teaching of mathematics to engineers:

1. Use all appropriate means to encourage better mathematics preparation in the high schools.
2. Teach "operational" rather than merely "appreciative" mathematics to engineers in the first two years of college.
3. Understand the engineers' needs and try to meet them, whatever the level of preparation.
4. Debate vigorously the issues involved in curriculum structure.
5. Make a serious attempt to introduce statistics and probability into the curriculum in the first two years.

Respectfully submitted:

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The New Position of Science*

By GILBERT E. DOAN

Manager of Metallurgical Research, Koppers Company, Inc., Pittsburgh, Pa.; Head of Department of Metallurgical Engineering at Lehigh University, 1939–1952

For the past hundred years we have looked to the methods of science to guide us to verifiable truth about the world we live in and to free us from old-fashioned dependence on tradition. The gulf between science and faith seemed too wide to bridge. We had to choose, and without admitting it to our conscience, we chose science as the most trustworthy guide.

Education in general gradually shifted its weight during that century from the classics to science. History, philosophy, and literature developed scientific foundations. Today even these "humanities" are pursued by scientific methods. Our universities have increasingly copied the German institutions where research is the primary concern.

Leadership of Science

Has science justified this 100 years of our confidence? Is its leadership still strong? Let us see what the leading scientists themselves answer today. Lord Bertrand Russell, one of the leading scientists, and a philosopher as well, says:[1] "It is a curious fact that just when the man in the street has begun to believe thoroughly in science, the man in the laboratory has begun to lose his faith.

"When I was young, most physicists entertained not the slightest doubt that the laws of physics give us real information about the motions of bodies, and that the physical world does really consist of the sort of entities that appear in the physicists' equations—Nowadays matters are quite different; the revolutionary ideas of the philosophy of physics have come from the physicists themselves, and are the outcome of careful experiments. The new philosophy of physics is humble and stammering, where the old philosophy was proud and dictatorial."

Certainly this admission, after 100 years of our deepest trust, must force us to reconsider our faith in the methods of science and in the findings of science, where they extend beyond the strict confines of the physical world.

Dirac, the great mathematical physicist, puts the case even more strongly: "Nature's fundamental laws do not govern the world as it appears in our mental picture in any very direct way, but instead they control a sub-stratum of which we cannot form a mental picture without introducing irrelevancies."

Have we, one might ask, been pursuing a will-o'-the-wisp in our devotion to science? Certainly it would appear so if we thought the scientific method had general instead of merely specific validity in its own field.

The Validity of Science

But Prof. M. Polanyi, F.R.S.[2] at Manchester University, England, presents the general summation to the question of the validity of science:

"The 'suppositions' underlying our

* Reprinted from *Mechanical Engineering* for January, 1955, pp. 28–29, with permission of Copyright Owner.

[1] *The Scientific Outlook*, p. 88, Free Press, 1931.

[2] "Science, Faith and Society," Oxford University Press, London, England, 1946, pp. 1, 17.

belief in science are more extensive than is usually thought. These suppositions co-extend with the entire spiritual foundations of man and go to the very root of his existence. Just as there is no proof of a proposition in science which cannot conceivably turn out to be incomplete, so also there is no refutation of a proposition in science which cannot conceivably turn out to have been unfounded."

Instead of getting at least one foot down on the solid ground of reality through the discoveries of science, it is clear that both our feet are still firmly planted in mid-air. Aside from its utilitarian value, which is great, science too is still a matter of *faith in suppositions.* It is clear that the miracles of science such as human flight, television, and the curing of disease are the fruits of a system which is built on unproved assumptions—*a faith, a creed* like the one we confess in church, only the creed of science is implied, not confessed.

Not only are the laws of science based on suppositions as is clearly revealed in the foregoing, but the outstanding findings of science repeatedly violate its own basic articles of faith. Let us be specific: For centuries Newton's laws governing time and space were accepted as physical fact, basic and immutable. Then Einstein modified Newton's laws. Today, time and space are no longer absolute quantities, but varying and uncertain things.

Again, the law of the constancy of energy was changeless "fundamental fact." It too was one of the "ultimate truths" of science. We brought all our discoveries to this law to test them. Then the atom bomb exploded and proved that new energy could be created out of mass, ($E = mc^2$). Today this so-called fundamental fact of the constancy of energy admits of exceptions. These are not corollaries of science, they are its ***basic articles of faith.***

Three-hundred years from today the "truths" of science will be yet more greatly changed. As Polanyi puts it, even the fundamental laws of science "carry within them the human assumptions which eventually lead to their decay." [3] We come closer to absolute truth with each scientific discovery but we never can say, "This will never change."

Alfred North Whitehead,[4] the mathematician and philosopher, carries us into the clear on the entire question, as usual:

"We supposed that everything of importance about physics was known. Yes, there were a few obscure spots, strange anomalies having to do with the phenomenon of radiation which physicists expected to be cleared by 1900. They were. But in so being, the whole science blew up, and the Newtonian physics, which had been supposed to be fixed as the Everlasting Seat, were gone. Oh, they were and still are useful as a way of looking at things, but regarded as a final description of reality, no longer valid. Certitude was gone."

Finally, Sir Winston Churchill [5] realizes this co-relative position of science and expressed it clearly at the M.I.T. Mid-Century Symposium. He said:

"No technical knowledge can outweigh knowledge of the humanities in the gaining of which philosophy and history walk hand in hand. Our inheritance of well-founded, slowly conceived codes of honor, morals and manners, the passionate convictions which so many hundreds of millions share together of the principles of freedom and justice, are far more precious to us than anything which scientific discoveries could bestow."

Thus leading scientists and statesmen have concluded that neither scientific methods nor scientific discoveries have freed man from reliance on faith. The scientists are quite frank in their admission. This disclosure challenges the

[3] "The Logic of Liberty," University of Chicago, Chicago, Ill., 1951.

[4] "Dialogues of Alfred North Whitehead," by Lucien Price, 1954, p. 7. Little, Brown & Co., Boston, Mass.

[5] "Mid-Century," J. E. Burchard, editor, M.I.T. Press, 1950.

position of American intellectuals in almost all fields. We had fondly hoped that our intellects would make us self-sufficient, that the worship of Deity would become unnecessary. But science can't do this. Let us see how this admission must change our teaching of science.

Democracy Also Based on Faith

In western civilization this admission actually revives our trust in the democratic way of life. Like science democracy, too, is based on faith, on belief in the objective existence of truth and justice.[6] The belief in objective justice, and man's obligation to practice it, are matters of faith, not proof. You cannot prove that man ought to be just; you cannot prove that we ought not permit the forcible repatriation of Korean prisoners.

These are parts of our basic faith. Thus the "miracles of science" achieved in the laboratory such as flight, radio, and disease control are paralleled by the "miracles of democracy" achieved in society, such as freedom, human decency, and prosperity. *Both science and democracy are the fruits of faith.* Knowledge and proof trail along afterward. Instead of a flimsy delusion, faith turns out to be the keystone of our western system, both in science and in democracy. President Eisenhower, in his inaugural address, endorsed this position by his personal example. We may not *prefer* a world founded on faith, but if that is the reality we ought to face it squarely as this country has in the past, with very great profit. Certainly it is better than a world founded on *fear* as is the Communist world. After decades of doubting democracy and envying the rigid logic of totalitarianisms we suddenly discover that our own system makes much better sense, that science, democracy, and religion under the Supreme Being are compatible elements of the western tradition. This is the meaning of the motto on our coins: "In God We Trust."

[6] *Fortune Magazine*, February, 1951.

What must be done as a result of the newly revealed position of science? Must we return to traditional thinking? Must science recede from liberal education, and will dogmatic thinking then return to its entrenched position? Must research and experiment cease? Certainly not! Science has great value as one of several approaches to truth. As a mature nation with heavy world responsibilities our colleges and universities must carry both programs—the transmission of the western tradition based on faith, and the advancement of knowledge through research. There is work for both the humanities and science.

The American Society for Engineering Education has sensed the need for humanities in the engineering curriculum, perhaps without fully realizing why they are essential in transmitting democracy. The Society recommended a minimum of twenty per cent of humanities in every engineering curriculum, and most engineering colleges have put this recommendation into effect.

But the fiduciary nature of science must be frankly admitted to students, for its foundation-in-faith is its basic characteristic. *Only when a student realizes that science is based on faith can he confidently accept the tenets of democracy and religion which are likewise based on faith.* To teach men and women that science is verified truth, which therefore renders faith superfluous, as we have been doing, is not only to teach a falsehood; it teaches a falsehood which makes minds unwilling to accept the tested tenets of democracy. Students in America are confused on the basic issues of life. No wonder Lenin, Stalin, Molotov, and Vishinsky have laughed at democracy for its confused thinking and contradictory teaching!

Faith and Free Society

A free society, such as ours, is *not* an open society where everyone can do as he pleases. It is one strictly dedicated to transcendent ideals. If we lose faith in

objective justice, charity and personal integrity, as the Marxists have done, then both our material prosperity and our freedom (free enterprise, academic freedom, religious freedom, and political freedom) must disappear as they did in Germany and Russia. These beliefs have survived in America more because of their *practice* in industry, in the home, and on the farm, and because of the influence of the church rather than as a result of intellectual leadership or college teaching. We could use a little more intellectual leadership at this point! The college also should *practice* these beliefs. For instance, the personal integrity of a student ought to be intensively developed there, as it is at the leading women's colleges under the honor system to-day.

America is still wedded to faith. This union, joined in Washington's and Jefferson's day, is still unbroken. It has born the marvelous fruit anticipated. We ought to acknowledge our faith with pride; teach it openly and *make no exception for science.*

There is some evidence that the colleges are beginning to integrate science with democracy and religion, the other major areas of western faith. If this integration is achieved, then the university again can become the backbone of our civilization. Science will contribute richly to truth without in the least discrediting the other major areas of faith. For us as individuals the need to choose between science and faith as a guide in our personal lives has disappeared. *Both are faith.* Once more men are free to believe! On this basis the whole of western civilization (and the whole personality of the individual, once he has repented of his idolatry of science) can again go forward.

In the News

The **National Science Foundation** will consider applications for the support of travel to assist a limited number of American engineers to attend the 6th Plenary Meeting of the International Association for Hydraulic Research, to be held from August 29 to September 2, 1955, at Delft, Netherlands. Application forms may be obtained by writing to the Division of Mathematical, Physical and Engineering Sciences, National Science Foundation, Washington 25, D. C. Applications must be received by May 1, 1955, in order to be considered.

Publication is announced of "Professional Engineering Registration Laws," a compendium of registration laws for professional engineers in the 48 states, Alaska, Hawaii, Puerto Rico, and the District of Columbia. The 614-page book has been compiled by Alfred L. McCawley, attorney and former Missouri State Senator. The compedium is the culmination of an extensive research project undertaken by Mr. McCawley under the sponsorship of the **National Society of Professional Engineers.**

Published at $8.75, the book presents, state by state, the exact legal requirements that must be met for professional practice. It is a reference volume designed for the professional engineer or the engineer-in-training who plans to practice on a permanent or part time basis in another state or territory.

The compendium covers in detail such elements of the state laws as temporary permits, fees and bonds, the filing of maps, certificate applications, education requirements, examinations, and public works projects. The laws are cited for reciprocity, registration renewals, corporate and partnership practice, revocation of registration, and violations and penalties.

The book may be ordered from the Trustee Publication Fund, Jefferson City, Missouri.

Engineering Education Behind the Iron Curtain*

By EDWARD KEONJIAN

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Fundamental difference between the educational system of the free society and the totalitarian state is that in the free society education is built around the individual, while in the totalitarian state it is the state itself, in behalf of which the interests of the individual must unconditionally be sacrificed. Consequently, a liberal arts education, which is so popular in the Western World and which provides only a broad cultural background, is unknown in the Soviet Russia, where the education exclusively serves the specific tasks in the National economy and world communism.

An exhaustive evidence of this philosophy in regard to Soviet universities can be found in the "Soviet Great Encyclopedia," V. 9, pp. 512, 1951, which states that the purpose of Soviet universities is ". . . to prepare highly qualified politically trained engineering personnel . . . devoted to the course of Lenin-Stalin, capable of . . . merging, in a Bolshevik way, scientific theory with the practical work of building a Communist society."

The exclusive emphasis on the state and its needs can be found almost in every text book including highly specialized text books in every field of science and technology. For example, even pure technical books, as "Testing of Radio Materials and Parts" (Kazarinovsky, Moscow-Leningrad, 1953) has this to say: "Creation of the technical base of the Communist society, introduces new problems to the people of our country. The science and technology must serve for realization of these problems."

It will be wrong to assume, however, that this philosophy is carried out in the Soviet higher educational systems only. From the day that the child enters the elementary school, he is trained to learn what is good for the State and only for the State. I remember very well one of the textbooks for elementary schools, from which Russian children of eight had to learn to read and to know about the rest of the world. Here is how the book is described by the former U. S. Ambassador to Moscow, W. C. Bullitt.

> ". . . above the title "America" was a drawing which depicted hideous men and women wearing jewels and elaborate evening clothes, dancing to the music of a jazz band while in a cellar below the dance floor emaciated children worked at factory machines. The text read: "America is a country where children of workmen and farmers are forbidden to learn to read and write. They are given nothing to eat but bread. At the age of six, they are put into a cellar to work at factory machines, while the rich dance over their heads."
>
> "Amused at first at the absurdity, I soon realized that this was no laughing matter. The first impression that Stalin's little slaves can get of my country would come from that picture and that lie. Thereafter, the children would be inclined to think of the United States with hatred and contempt."

When the ambassador showed this book to one of the Soviet Ministers and asked how they can teach the children such ridiculous untruths, he received a reply from the Soviet Minister which stated:

* Presented at the ninth annual meeting of the Upper New York State Section of ASEE, on October 22, 1954, in Ithaca, New York.

". . . we shall teach the children exactly what is good for the Soviet Union to have them believe."

The same techniques of deliberate distortions of the truth can also be found in the textbooks of the Soviet high schools. Following the rule that "we shall teach them what is good for the Soviet Union to have them believe," the American history in Soviet textbooks is just history of lynching of negroes, history of American gangsters, of Sacco and Vanzetti (I lived next to the plant named after Sacco and Vanzetti), of Chicago slums, of economic depressions, strikes and so on. On the other hand, such basic subjects as mathematics, physics, chemistry, geography and others, are taught thoroughly and high school pupils are well prepared for entering into universities.*

Dut to the this fact, the Soviet universities do not have to spend part of their program on the fundamentals, which leave more time to go deeper into specialized subjects, and, of course, also more time for indoctrination courses, such as the fundamentals of Marxism, Leninism and Stalinism. Thus, from the very first days in school, the student is educated as a specialist and his entire curriculum is made up to meet the need of National Economy and World Communism.

The methods of teaching in the universities that have been developed through many years in old Russia, have been extensively and drastically changed several times since the Communists took over, and textbooks, even highly specialized, have been revised several times in accordance with the frequent changes in political situation in Soviet Russia and numerous purges.

How are universities and engineering schools organized in Soviet Russia today?

There are two types of universities in Soviet Russia:

(1) Regular universities for pure theoretical specialities such as physics, astronomy, mathematics, etc. as well as for preparation of high school teachers. It requires five years to graduate from there.

(2) Institutes which have the same university standards, but are more specialized.

In Soviet Russia, the majority of schools are of the second type, i.e. highly specialized. For example, according to official information, among 887 various Soviet schools of university and college standards (in 1953), there were only 32 universities with approximately 87 thousand students. The rest of these schools (i.e. 96.4%) were comprised of 167 technical institutes with approximately 240 thousand students, 90 agriculture institutes, 72 medical institutes, institutes of economics, physical culture, etc.

The technical institutes are of two following types:

(1) Polytechnical institutes, which generally are located in large cities and have approximately one dozen faculties.

(2) Specialized institutes such as institutes of Electrical Engineering, Mechanical Engineering, Chemical Engineering, etc., each with 5 or 6 faculties or departments.

As you can see, the institutes as well as the faculties in these institutes are more specialized than here. It is interesting to note that the people in Soviet Russia believe that American universities are specialized at much higher degree than the Soviet institutes.

In spite of this narrow specialization, the fundamental subjects, such as advanced mathematics, physics, electrical field theory and others, are compulsory for most of the specialized institutes, and during the first two years, the students

* Recently, the Soviet leaders emphasize that most of the students finishing the secondary schools will not take further full-time schooling but will go directly into the labor force. Therefore, in the Communist view, the main responsibility of Soviet schools is to train boys and girls "to love work" and to observe academic discipline that can be translated into "labor discipline" as soon as the students take their first jobs.

have to study these subjects very thoroughly. The special subjects start usually toward the end of the 3rd year of the school and continue in the 4th and 5th years. For example, as a student in electronics specialization, I had to study such subjects as communications, vacuum tubes, high frequency measurements in second and particularly in the third year of my school. During the 4th and 5th years, I had to take such specialized courses as radio antennas, microwaves, transmitters, receivers, etc.

No Elective Courses or Humanitarian Subjects

It should also be noted that the Soviet institutes do not have any elective courses or any humanitarian subjects whatever. Instead, the students in every university and institute are obligated to take certain political courses every year of school, even if one stays in the school after his graduation to complete his doctorate.

What are these political subjects?

1) Fundamentals of Marxism and Leninism
2) Political economics and economical politics
3) Dialectical materialism
4) History of the Communist Party

These political subjects are introduced into the curriculums of every technical school in accordance with the rule which was quoted previously that the purpose of Soviet universities is ". . . to prepare highly qualified, politically trained engineers . . . capable of merging, in a Bolshevik way, scientific theory with the practical work of building a Communist Society."

Officially, the political subjects comprise 8% of curriculum of the engineering schools, while 25% of the time is devoted to the basic courses and 65% to special courses. Actually, the political subjects take at least 10% of student's time and are always regarded to be much more important than any other subject. The brain washing is a very important process in every school of Soviet Russia, and the Soviet Government never fails to prove it by expelling students immediately from the schools as soon as they fail in one of these political subjects.

Everybody in Soviet Russia takes this for granted and the only trouble is that the professors who teach political subjects are usually expelled more often from the universities than the students. This is due to the fact that professors of political science are members of the Communist Party. For them occasional misinterpretations of the fundamentals of Marxism, or wrong examples which they might use to illustrate certain laws of Marxism, are equivalent to state crime.

The curriculums of the technical institutes usually require 10 semesters, of which 16 weeks should be spent on practical work in industry and last semester on the preparation of diploma project, which is equivalent to a Master's thesis in this country with the exception that in Soviet Russia, the diploma has to be defended publicly by the student.

After a student is out of school, he automatically receives his job assignment and must go to any place where the government will send him at salary which the same government will find appropriate to pay him. Officially, one has this compulsory work for the first 3 years, only, but actually after the 3 years are over, the management automatically extends the term for another 3 or 5 years. In some cases, when a student displays good and unusual ability in the teaching profession or in research, the school will keep him after graduation for another 3 years for graduate study and research work. At the end of this program, he has to make another thesis for his "candidate" degree which is equivalent to Ph.D. in this country. In order to receive the Doctor of Science degree, the holder of a candidate degree has to spend a few more years for extensive study of advanced courses and has to accumulate enough experience in research, before he can be entitled to public defense of his last

doctor's thesis, which should be an original work of significant value.

Doctor's degree can be awarded also to some outstanding engineers and scientists without examinations, and without thesis, providing that they have at least 20 years practical experience in research and engineering and have contributed a great deal to the science or to technology of the country.

Student Organizations

The Soviet schools do not have any special student clubs or fraternities since the Soviet Government never trusts any organizations which are not organized by the state and which are not supervised by the secret police. The same is true about students' sports organizations. Athletes may join the only two existing clubs: Dynamo or Sportac, which are operated directly under the supervision of the ministerium of secret police.

If someone displays outstanding ability in athletics and desires to become a professional sportsman, he will be admitted into a special institution of Physical Culture. One such institution named Lesgaft was located in Leningrad. In this institution, students spent 4 years of intense physical training under permanent medical care, to make them outstanding professionals. After graduation from these schools, the government sends these professionals as "amateurs" into various countries to compete with Western amateurs and to beat them, so that the Soviets can get the maximum propaganda out of this. The government invests millions of dollars in this, but it pays off as you can see from the recent results of the Olympic games in Finland, Sweden and England.

Who Are the Professors in the Technical Schools?

A great number of them consist of specialists who managed to be transferred from industry into the schools, though such a transfer reduces the salary of the specialists.

An explanation for this lies in the fact that when a specialist works too long in the industry of which 9 out of 10 are classified projects, he knows that if he fails, he can very easily be accused of being a saboteur and be sent to a concentration camp. Therefore, many specialists and scientists prefer to switch to university work before they can be banished. The Soviet universities usually benefit greatly from such a situation because, in this way, they are able to add many good specialists to their staff.

There are no religious studies in the Soviet universities. No programs of foreign universities can be found in the libraries of the schools, as well as no foreign students can be found in Soviet universities, from the Western countries.

There is no association of university professors which is concerned with the problems of academic freedom, or international conventions, conferences, exchange of information or teaching methods with universities, etc., in the Western countries.

In each subject, the professor must introduce political fidelity and has to match his subjects somehow with the fundamental principles of dialectical materialism. If he fails—he cannot stay in the school.

Conclusion

1) The final aim of the Soviet Government is the conquest of the world and, consequently, all the efforts of that country, all the resources and manpower, are directed toward that basic goal.

2) One of the essential means to reach this goal is a highly developed industry which is able to produce enough military equipment.

3) To run this industry, the Soviets need a large number of good engineers and therefore spend enormous sums of money for the education of these engineers. Today, the Soviets prepare approximately 30,000 engineers and 110,000

technicians every year, who almost entirely are absorbed by the military industry.*

4) The engineers in Soviet Russia cannot be only professionals, but they must also be politically educated. Therefore, in all technical schools, political subjects are compulsory and no engineers can graduate from any school without being completely familiar with the Communist's interpretation of polities and world affairs.

5) Tremendous programs of expansion of military industries and the preparation of thousands of engineers are not indications of any prosperity in the Soviet State, since it is usually carried out at the expense of the civilian economy, lowering the producion of common goods and the living standards of the people.

6) There is, however, one more important point. The Soviet system has completely destroyed the most precious of man's birthright, which is his personal freedom, and for which there is no substitute.

This is a fact which some people prefer to ignore when they enthusiastically praise the "wonderful achievements" of the modern slave state called the Union of the Soviet Socialistic Republics, or USSR.

* According to the latest information, the number of engineers graduating from the schools in Soviet Russia in this year reached 50,000; however, this figure could be slightly exaggerated by the Soviet statistics for propaganda purposes.

College Notes

The **University of Michigan** announces a two week intensive course on Nuclear Reactors and Radiations in Industry to be given in Ann Arbor, August 15 to 26, 1955. The course is sponsored by the Nuclear Engineering Committee of the College of Engineering, and will be conducted by members of the Engineering College staff, assisted by guest lecturers. Staff members participating include Professors L. E. Brownell, H. J. Gomberg, W. Kerr, H. A. Ohlgren, and J. R. Sellars.

Lectures covering such topics as elementary nuclear theory, measurements of nuclear radiations, interaction of radiation and matter, and nuclear reactors and fuels will be coordinated with laboratory demonstrations, tours of University radiation facilities, and examples of industrial applications. Guest lecturers from industry will present current progress and thinking in the nuclear field. The one megawatt University of Michigan research reactor, which will be under construction during the course, will be inspected and discussed. Demonstrations using a multikilocurie gamma radiation source will be conducted. The course is intended for the engineer without previous experience in nuclear technology who wishes to acquire a knowledge of representative problems and techniques in this rapidly developing field.

Tuition will be $200. The fee includes a complete set of printed course notes.

For further details or for information on application, write Professor William Kerr, Department of Electrical Engineering, University of Michigan, Ann Arbor. The deadline for registration is June 1, 1955.

What Is Industry's Responsibility in the Training and Development of Engineers?*

(From the Viewpoint of Industry)

By FRANK J. LOCKHART

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Why is a company in business? What is its primary objective? To render a profit for the owners? To provide a commodity for its customers? Such questions have been debated over and over, usually to no definite conclusions. It appears to me as if we can get a better understanding by recalling the fable of the six blind men who were asked to describe an elephant after touching it. The first blind man approached the elephant, touched its ear, and said "Why, an elephant is like a big leaf." The second touched the elephant's trunk and said "An elephant is a big snake." The third touched the elephant's tusk and decided it was a spear. The fourth touched the elephant's side and said "The elephant is a wall." The fifth touched the leg and said "The elephant is a post." The sixth blind man touched the tail and said "The elephant is a twig." All of these men were right—in a very limited extent. But people of vision are able to see these individual parts in proper perspective and determine what an elephant does look like.

So it is with the primary objective of a company, or industry. From the limited viewpoint of the owners, the primary objective is to make a profit. From the limited viewpoint of the customers, the primary objective is for the company to provide a commodity. From the limited viewpoint of the vendors, the objective looks different. And likewise, from the viewpoint of the employees—as well as from the viewpoint of the community neighbors. Certainly the viewpoint of the competition is different from any of these above. Now we realize that each of these views is correct—in a limited extent. With broader vision we can see that the primary objective is six-sided, with each face different in appearance from the other five.

Such an interpretation of the objective of a company or industry is held by more and more industrial leaders. It is a broader interpretation than any held previously, and is the long-range viewpoint accepted by companies planning for the future.

Now as to the prime function of a company or industry. Using the word "manufacturing" in a broad sense, we can say that all companies are manufacturing something, in that they first take raw materials, and second perform some processing or manufacturing operation on them, to arrive at a finished product or commodity. A company or industry does exactly the same "manufacturing" operation with respect to its employees; first it hires people with certain qualifications (or specifications), and second it trains or develops these people, again to arrive at a finished product, mature, capable specialists or administrators.

* Presented at a meeting of the Educational Council for the Engineering Societies in Los Angeles, October 27, 1954.

Historically, companies have kept balance sheets on the material things. Today, companies planning for the future also keep balance sheets on manpower resources and requirements. Why? Because it is realized that the value or worth of a company *is* the quality of its people. Please note that I did *not* say "*depends on* the quality of its people," I said "*is* the quality of its people." In the final analysis, people do the work; people do the manufacturing. Machines can only help the people. If you want to see the machinery fall apart and the raw materials wasted, take the human element away.

I'm certain there are a number of skeptics who consider the foregoing as a collection of nice ideas—"but after all, isn't the success of business still measured by profit?" That comment is true based on a short term operation—because the other items involved in the objectives and functions can not be put down in cold, hard figures on a balance sheet. They are intangibles on a short term basis. My point is that modern industry recognizes the importance of these intangibles even on a short term basis, although they do not appear on the financial sheet.

Most engineering educators recognize the similar situation involved in the giving of grades to students at the end of the semester. You may, by rules of your accounting system, be forced to give a *C* to a student you know is superior to another student who receives an *A*. In such cases you will give a higher recommendation about the *C* man, and thereby try to take the intangibles into consideration.

The above objectives and functions of industry are the basic principles of what many people call "scientific management." You will recall that the engineers are rightfully credited with giving first recognition and impetus to scientific management, which is now recognized as *not* the direction of things, but as the development of people.

General Area of Training

We consider engineering education, training, and development as a joint responsibility of universities and industry. For convenience let us consider the subject in terms of the following areas:

(1) Basic and applied sciences;
(2) The "art" of engineering;
(3) Professional ethics and behavior;
(4) Personal characteristics;
(5) Human relations.

No one of these areas is the exclusive domain of the universities or of industry. Universities and industry both must participate to some extent in all of them.

Realizing that engineering graduates are the end product of the university and the raw material for industry, I feel compelled to discuss the university's responsibility in the training of engineers before discussing industry's responsibility.

The University's Responsibility

In the first area, basic and applied sciences, the university has rightfully assumed the major responsibility and is doing an excellent job.

In the second area, the "art" of engineering, the university has played only a minor role, leaving this to industry. This is understandable because of the short time available for university training and the great number of entirely different industries which employ engineers. What is practical for one industry can not be used by another. Furthermore, most students do not know what industry they will enter, so would be unable to specialize so early.

The third area, professional ethics and behavior, is one where the university has not participated as much as it should. It is felt that the university can contribute in this area by introducing senior students to the Code of Ethics, and by discussing various problems such as labor unions, professional registration, and various professional societies.

The fourth area, that of personal char-

acteristics, is one shared perhaps equally by the university and industry. The university has not contributed its share towards training in this area. I would like to be more specific in three ways:

(a) In the area of physical appearance and mental attitude, attention is called to the many articles and pamphlets dealing with the personal interview, with the various kinds of jobs inside the different engineering fields, and with aptitude testing. Such topics would be very helpful for discussion with senior students.

(b) I am convinced that conventional engineering education smothers originality, imagination, and initiative. And these are the very qualities which industry and our country need. Too often, young engineers are parasites of the experts—either those people who write the books or the professors. For example, many schools, or books, or professors make one such serious mistake in introducing students to the so-called "scientific method." After the problem has been defined, students are instructed to make a literature search immediately, to see how others have handled the same or a similar problem. That in itself puts blinders on the students' eyes—again they are parasites of experts.

(c) Not enough attention is given at the university to perspective and to a sense of proportion. This criticism applies to each of the time-honored engineering working habits of accuracy, speed, and neatness. Too much accuracy is silly, not enough accuracy is tragic; too much speed is waste energy, not enough speed is dilatory; too much neatness is pompous; not enough neatness is sloppy. Too much or too little of any of these factors is expensive and wrong. University training can place more emphasis on the proper sense of proportion in working habits as well as on the proper perspective in maximizing important things and minimizing those that are trivial.

The fifth area, that of human relations, is one well-known to engineering schools today. Well-known, if for no other reason, because of the wide spread *fad* that engineering students need to take more courses in the humanities. There is no doubt that industry finds the engineering graduates deficient in communications —both oral and written. The average engineering graduates are lacking in understanding the universal need for salesmanship. I personally believe the engineering graduates are deficient in understanding of the qualities of leadership and the understanding of good citizenship. Some, but certainly not all of these deficiencies can be corrected by the engineering schools. Most of these deficiencies may be placed directly upon the liberal arts schools, or the arts and sciences schools, or whatever you call them —and especially upon the present courses in humanities taken by engineering students. The primary error? Definitely not the number of courses, but the quality of the present courses and the instructors. It appears to me that the engineering faculty should resist diluting the curriculum with more of the same type humanity courses, and should insist on upgrading or revising existing ones.

Industry's Responsibility

In the first area, basic and applied sciences, industry has done little, leaving this area almost exclusively to the university.

With respect to the "art" of engineering or practical application (the second area), it has been pointed out that the university can not assume responsibility for training. This is industry's responsibility. Companies of appreciable size recognize and accept this obligation. It has been pointed out many times that in the structural field the smaller engineering companies cannot afford to train young engineers. From direct personal experience, I know that the small engineering companies *can* afford to train engineering graduates in the fields of chemical, electrical, industrial, mechanical, and petroleum engineering. It is done every day. I cannot speak with authority about

the fields of civil and structural engineering; but in view of the overwhelming evidence in all other branches of engineering, I am compelled to ask the question: "Is structural engineering so entirely different from all other engineering?" I cannot believe that. If smaller companies can *not* afford to hire and train engineering graduates in structural work, then could it be the fault of the university training in this field?

The third area, professional ethics and behavior, is one which must be taught by the university and developed by the efforts of the engineers themselves. Industry is certainly receptive to such aims and encourages them. But I personally believe that industry's responsibility in this area is to provide the proper climate for individual growth.

The fourth area of training, that of personal characteristics, is one in which industry has changed remarkably during the last twenty years. The change has been from a "sink or swim" attitude toward the young engineers to that of constant guidance and counseling. This change in attitude may be attributed to "scientific management." Such activities are being worked on constantly and training in this area will continue to improve.

Human relations, the fifth area of this discussion, includes communications, salesmanship, leadership, and citizenship. Industry again has accepted its responsibility for training in these areas, and will expand its efforts. Companies are training their people and encouraging them to seek outside training in oral and written communications, in the art of gentle persuasion, in salesmanship and leadership. Companies encourage (and in many cases insist) their people take active part in community affairs. Participation in church affairs, governmental work, various charities and community projects, jury duty, and many others are some examples of this.

Now that we have talked about industry's *responsibility* in training and development of engineers, just exactly how can industry do these things?

How Industry Can Help the University

Industry can aid the university in training the engineering students in a number of ways, such as:

(1) Informing the university of industrial trends which suggest additional or improved engineering training;
(2) Rendering financial aid to the university and/or students to meet rising costs;
(3) Offering "on-the-job" training to educators and students by summer work, part time employment or consulting, cooperative educational programs, and "exchange" plans;
(4) Offering the services of professional engineers and managers, when requested by the university, to give lectures and teach special courses;
(5) Offering instructional aids such as technical bulletins, exhibits, and models.

Most companies participate in one or more of the above activities, and all companies desire to aid the university in all possible ways. I personally think that the university does not ask industry for nearly enough of such help.

How Industry Can Train Engineers

After graduating from the university, young engineers are ready to start their industrial training. Industry aids in this training in a variety of ways, some of which are:

(1) Encouraging further education, such as graduate work, special courses at the university, night-school classes, and short term courses of various organizations;
(2) Encouraging high professional standards by recognizing professional registration and technical society activities;
(3) Utilizing formal training programs of the proper quality.

However, it appears to me that the most important principles of training and developing engineers in industry are:

(4) Training should be done mainly by the company in terms of its own policy, practice, and need, rather than by an outside agency;
(5) Training should be a direct responsibility of the line supervisor as an emphasized part of his job duties—that is "on-the-job" training.

In summary, the training and development of engineers is a joint responsibility of the university and industry. The university does the major share of training during the school years, aided to a minor extent by industry. After the young engineer graduates, industry does the major share of training, aided to a minor extent by the university. Training is now recognized as being an everyday part of every industrial supervisor's job. What is industry's responsibility? We have discussed the broad way in which industry views its objective, and how industry realizes that its true worth is the quality of its people. Industry must improve the quality of its people, its engineering specialists and engineering administrators in order to survive.

College Notes

A Special Summer Program on "Industrial Applications of Heat Transfer to Electronics" will be offered at the **Massachusetts Institute of Technology** during the two-week period of the 1955 Summer Session from June 14 through June 24. Professor Ernest H. Huntress, director of the M.I.T. Summer Session, says that it is primarily designed for "engineers in research and development fields of electronics, electrical engineering, and mechanical engineering, who feel the need for better facility with the basic concepts, design methods, and applications of heat transfer."

The Summer Laboratory Course in Techniques and Applications of the Electron Microscope will be given again this summer from June 13 to June 25, 1955, by the **Cornell University** Laboratory of Electron Microscopy in the Department of Engineering Physics. The course, under the direction of Professor Benjamin M. Siegel, will have Professors Cecil E. Hall of M.I.T., Cambridge, Mass., and Robley C. Williams of the University of California, Berkeley, Calif., as guest lecturers this year.

The course is designed to give members an intensive survey of basic theory and interpretation of results. The registration is limited to a small group so that ample facilities are available for each one to pursue laboratory work in his special field at an introductory or advanced level depending on his previous experience. Further inquiries should be addressed to Professor Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

The **University of Kansas City** and **Cornegie Institute of Technology** will cooperate in a five year educational program leading to both liberal arts and engineering or science degrees. The program will go into effect September 1955.

In the plan, students will take three years of liberal arts with a major in science at the University of Kansas City, then transfer to Carnegie Tech for two years of engineering or science. At the end of five years, they will receive bachelor of arts degrees from Kansas City and bachelor of science degrees from Carnegie

Personality Factors in the Learning Process*

By W. R. LePAGE

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In spite of some rumblings on the horizon, college teaching still predominantly follows the traditional pattern whereby it is assumed that knowledge of the subject and ability to lecture clearly is all that is required of a teacher. We tend to assume that the student will receive and retain subject matter that is poured into him. Of course, this statement oversimplifies and exaggerates; nearly every teacher sooner or later comes to an empirical realization of the importance of certain conditions which must be met within the student if he is to learn. For example, we instinctively tend to realize he must have a goal (that he must want to know the subject), that he must be motivated so that he will listen attentively and study, and that he needs active participation in problem solving.

Following this intuitive approach, we teachers tend to acquire techniques in agreement with principles which have been established by specialists in education. We try to make our lectures interesting, we try to develop exercise problems that will excite their interest, we look for well written text books, and the like. Nevertheless, I think most of you will agree that many times these devices are disappointingly ineffective. Very often capable students do not respond, and almost always the response is less than desired. To illustrate, let me list a few examples from my own observations.

A well-prepared lecture, skillfully organized, may not get across to certain students;

Many students miss questions on examinations which we know they are equipped to answer;

Certain students always get about the same low grade, no matter how easy an examination may be;

Special concessions to students with hard-luck stories usually serve only to increase their demands for special treatment;

Some students may not avail themselves of faculty offers of help.

It is natural to ask ourselves why students only partially respond to our efforts to help them learn, and sometimes do not respond at all. We are perhaps prone to pass it off by saying some students are stupid, or lazy, and to assume we, as teachers, have done all we possibly can do to be of help. However, I believe problems of this sort are important enough to warrant critical study. Unresponsive and uncooperative students are important. Although they may be in a minority, they take up a disproportionate amount of teacher time, and they disorganize and retard the class. Also, unresponsiveness and uncooperativeness is not confined to poor students. I once knew a student who was practically incapable of turning in a laboratory report. He flunked one course because he didn't turn in any reports at all; but his performance in recitation courses showed that he had better than average technical ability.

My awareness of the importance of these phenomena has been growing over the past five years, starting from a rather accidental introduction to some of the modern theories of educational psychol-

* Presented at the Central New York ASEE Meeting at Cornell Univ., Oct. 22, 1954.

ogy. From formal and informal study † I acquired a viewpoint which seems to me to go far toward offering a deeper understanding of student behavior. I would like to share this viewpoint with you. In doing so I emphasize that a person studying in this field tends to develop his own private set of ideas; and therefore I will present my digest of what I have learned from others. I do not present myself as a psychologist, but as an engineer interested in problems of education. My discussion will of necessity be presented in the language of the layman.

We begin by noting that in teaching we are essentially interested in changing a person's behavior in a predictable way. Accordingly, we temporarily digress into the general subject of human behavior in order to enunciate a central postulate upon which my thesis will be based. This postulate states that *the response of a person to a stimulus is determined by how that stimulus is perceived by that person.*

This idea seems simple and logical enough. In fact, I would expect that most of you would say it is certainly true. However, this rather simple hypothesis has subtle meanings which have seemingly escaped conscious acknowledgment up until quite recently. It is these meanings which will be partially explored in the remainder of this paper.

Importance of Perception on Behavior

As an extreme sample of the importance of perception on behavior, suppose two persons are thrown into the water. One is a swimmer, and the other is not. Both receive the same stimulus; but their behaviors will be widely different. The swimmer perceives a familiar situation, and swims. His response is organized. The non-swimmer perceives the stimulus as a threat to his well being, and his response is disorganized.

† Particularly with Drs. K. M. Peterson and A. W. Coombs, both formerly of the School of Education, Syracuse University.

Another example comes to mind, which comes a bit closer to the teaching situation. In his book "A Smattering of Ignorance" Oscar Levant tells an anecdote about about a French-horn player in an orchestra conducted by Toscanini. The horn player had done a difficult passage flawlessly many times. Finally, one day Toscanini complimented him on his fine playing, mentioning how difficult the passage was. The next time the orchestra played the piece the horn player stumbled through it—with dire consequences afterward, as you may imagine. His behavior had changed. Why? In terms of the ideas of this paper, his response to his cue had changed because his perception had changed. Originally he had not perceived the passage as being particularly difficult; it was well within his capabilities, he thought, and he responded accordingly. He played it well. After being complimented he perceived the passage as difficult; in fact, from his stumbling performance, we may say that he perceived it as being too difficult for him. He was like the non-swimmer faced with the need to do what he perceived himself as unable to do. Therefore, like the non-swimmer, his response was disorganized.

We see that these two examples have a similarity, but they also have a difference, and this difference is significant. When the non-swimmer perceives that he cannot swim he is correct—in truth he cannot swim. In the case of the horn player, at the time of the disastrous performance his perception is inaccurate. He can play the passage—he had done it many times—but this fact means nothing to him at the moment. As far as he is concerned, at that time, it is too difficult for him.

Here we have an idea with broad implications. As was said before, response is dictated by perception of the stimulus. But now we have the important addition that *the perception may be grossly inaccurate.* This is why a person's behavior may seem strange, ir-

rational, or even bizarre to an observer. The observer does not know the perceptions of the behaver. When the observer can know the perception of the behaver, the behavior seems rational. An observer of the non-swimmer, if he knew he was a non-swimmer, would not be surprised at the disorganized response. However, in the other example we can speculate that Toscanini's perception of the situation was unchanged, and therefore that he probably did not understand the horn player's behavior.

To recapitulate, the behaver responds to the stimulus in accordance with how he perceives the stimulus, and this perception may be in error. I restate this because I want to phrase it in another way, as follows: *The behavior of a person always makes sense when viewed in the light of the way the situation seems to him.* Thus, in teaching situations, if a teacher can acquire a feeling of how the situation appears to the student, the student's response will make sense to the teacher.

One more modification is needed. The behaver's response may seem to be irrational to himself, as well as to another person. In other words, he may not be conscious of the inaccuracy of his perceptions, and if so he cannot understand his behavior either. To go back to the example of the horn player, he was not aware that he regarded the passage as being too difficult for him. We can be certain of this, for if he had been aware of it he would have arranged to be absent from the performance.

We are now down to the kernel of our theme, and are ready to justify the use of the term "Personality Factors," in the title. Inappropriate behavior occurs when perceptions are inaccurate, and inaccurate perceptions are likely to be unconscious. We will dwell mostly on the unconscious ones. Why do individuals have unconsciously inaccurate perceptions? We can loosely say that unconscious perceptions are influenced by personality, but this answer is not good enough. What do we mean by personality? When I put this word in the title I mean something like this: it is the sum total of all the feelings a person can have about himself. The feelings he can have about himself as a man or woman, as a student, as an athlete, as the offspring of his parents, as a memmer of society, to mention a few.

I say feelings, rather than thoughts, in order to emphasize their subconscious nature. These feelings are deeply rooted in a person's past, and we all have them. Our society being what it is, we may easily grow up with feelings of inadequacy in some of these areas. If a stimulating situation touches on an area in which we feel inadequate, the anxiety about our inadequacy may cause an inaccurate perception, and a disorganized response.

Before developing this theme further, we should note that inaccurate perceptions are not troublesome if they are conscious, because they are easily recognized and corrected. This is what happens in a successful learning situation. Here is an example. Imagine a person who had never seen an ice-covered street. He might perceive it as being like asphalt, and his behavior would reflect the inaccuracy of his perception. After a few gyrations he would fall down. However, immediately he would understand the inaccuracy of his first perception, and it would not happen again. He would have learned, and his perception would have become more accurate. In fact, if he were told ahead of time what to expect he would not need to fall down at all, provided, of course, he knew enough language to understand. In other words, a "teacher" could help him to sharpen the accuracy of his perceptions ahead of time, just as when we demonstrate a method of problem solution in a class room. Those with the language equipment and background to understand the demonstration will be able to do a problem like it without "falling down." A person with less understanding will need

to "fall" before his perceptions will be accurate, but if there are no subconscious perceptions distorting his view he will learn from the "falling" experience, because he can see what was wrong.

These ideas can be organized into a definition of learning. In the framework of this trend of thought, I would suggest that learning is a process in which the student responds to a sequence of new stimuli, with continually increasing accuracy of perception. When a mistake is made the inaccuracy of perception which caused it is consciously recognized by the learner, and adjusted accordingly. Thus, when learning is taking place the student's conscious perceptions are slightly more accurate each time a situation arises. Although repeated mistakes may be made, if learning is taking place these mistakes will all be different, however slightly. Emphasis is on the idea that in learning the learner must have an accurate evaluation of his own perceptions which are relevant to the subject.

Learning May Be Inhibited

If he has a subconscious inaccurate perception, which is relevant to the situation, learning may be inhibited. Being unaware that his perception is inaccurate, he can do nothing about it, and he will make the same mistakes repeatedly. In such a case learning is possible only after the inaccurate perception is removed. But its removal will not be accomplished by dealing only with the subject matter to be learned. As we go on I will suggest how it may be possible to help a student escape the bondage of inaccurate subconscious perceptions, and thereby to release him to become aware of, and to deal with, the real problems of learning. I shall also suggest that this phenomenon may be much more prevalent than you may suppose.

We return now to the subconscious perceptions, considering them in somewhat more detail. I will cite an example of a student whose perception I believe was inaccurate and subconscious. At one time I was helping out in a freshman orientation program, leading a discussion group. In reply to one of the students, who had expressed the feeling that in one of his classes there was not enough student participation, I mentioned that I believed most teachers would welcome constructive comments from members of the class. After the class was adjourned one student came to me and said I was wrong. "No teacher would welcome criticism of any kind" he said, with great emphasis. I accepted this as his viewpoint, and discussed it with him at some length, but he was adamant in his belief. We might suspect that he must have had an unfortunate experience with a teacher at some time. If indeed this was the case, he had generalized it to all teachers, and he had no room for any thought that there might be an exception. Note that while he was denying the possibility of a teacher accepting criticism, he was mildly criticizing me. In other words, his action at the time was to some extent disproving his contention. But this did not change his viewpoint, and I believe the reason is that he had a subconscious inaccurate perception of teachers.

Of course, I must admit that I did not know the person well, and I cannot be sure of my analysis, but I think it will be useful to speculate as to what that perception may have been. The speculation is this: that this student felt his relation to teachers to be much the same as a very young child might feel toward his parents—the feeling of being in the presence of an authoritarian, unyielding influence. In the teacher-student relationship he felt subordinate and ineffective.

To go on with this theme, have you ever noted that with some students it is impossible to give a quiz easy enough for them to pass? Easy or hard, the grade is always about the same. We may speculate as to the perception of such a student as he sits with exam paper

in hand. Perhaps in his school experience he became thoroughly convinced that he was a poor student, so that now he feels like a poor student. He literally cannot imagine himself getting a good grade. He would not feel like himself if he did. Perhaps you can remember occasions in your own life where you have not felt like yourself—you would say you felt out of place. It is an uncomfortable feeling, perhaps like a temperance worker would feel if dragged into a beer hall. We do not like to feel uncomfortable, and neither does the student. And what can this do to his perceptions? He cannot read a question and perceive that he knows the answer. His subconscious need to feel like himself—a poor student—causes him to see no relationship between the question on the paper and what he knows. He subconsciously knows the questions are too difficult before he looks at the paper.

There is another possible explanation, based on a somewhat different perceptual distortion. Perhaps, like the student mentioned earlier, he feels that teachers are his authoritarian masters who are "out to get him." He may feel that teachers take sadistic delight in concocting impossible questions. If this is the way he feels, all questions will be impossible to him. He needs to feel dominated and pushed around by the teacher—otherwise he will not feel like himself.

At this point I would like to inject a word of caution. I am not suggesting that all causes of poor student performance can be explained in this way. I am suggesting, however, that effects such as I am describing do reduce our productivity at times, and that in some cases the effects can just about smother all latent abilities.

I have spent quite a bit of time dwelling on the feeling of student in relation to the teacher. This is by no means the only type of feeling we might consider, but it seems to be the most appropriate one, since we are dealing with the learning process. An important distinction must be made, however; I am not talking about a conscious attitude toward a specific teacher, but rather a generalized feeling toward an *image* which the student has, and which image he applies to each teacher. In the earlier example, the teachers who (in the student's mind) would not listen to the student's suggestions were not real flesh and blood teachers; they were the student-created images which he superimposed upon them. Therefore, to him all teachers were alike.

If this sort of distorted generalized image is so important, perhaps we should consider briefly how it can come into being. It is perhaps not surprising that we all have such images to some extent. It is quite common in our feelings toward officers of the law, sometimes toward anyone in uniform, or in government, to cite some examples. These feelings have roots going back to early impressions, gathered when we were too inexperienced to evaluate situations for ourselves. For example, a child needs to be told only a few times that if he does not behave a policeman will "get him" in order for him to have a distorted image of a policeman. He does not know enough of the facts to form an accurate image. And these images can persist literally for a life time. In later life such a person learns more about policemen, but he may still not really be sure that a policeman is a human being, in the same sense that he knows his neighbor is a human being.

I can remember being surprised, as a child, to find that my teacher lived in a house more or less like mine. To me teachers were sort of non-human mechanical people, who perhaps crawled into the walls when the class went home. I felt they didn't have families and relatives.

I am hoping that these examples will have recalled to your minds some similar thoughts of your own. If this is possible it will make my words seem more meaningful to you, and improve our com-

munication. From talking with many persons I am quite sure that feelings of this sort are quite common.

Before going on to discuss some of the ways in which I think we can minimize these effects in the learning situation, let me mention one more example. From my college days I remember the prevalent belief among students, which I shared to some extent, that a teacher's evaluation of a composition or report was based on its bulk. Here again we have the generalized image which was superimposed on all teachers. I did not consciously believe it, but nevertheless I would still feel uneasy about turning in a short, but well done, report. This myth (and I think you will agree with me that it is a myth) is still around our campus. The other day I was talking to a typewriter salesman. He told me that students prefer the large pica type, because with it they produce more pages per composition.

In terms of the total student, I have probably allocated a disproportionate amount of time to the teacher image. Earlier, however, I talked about the feeling toward self; the image of self so to speak. As we go on I would remind you that this is no less important, and perhaps more important. Bear in mind that the student may superimpose upon himself an inaccurate image, in the same way that he can superimpose an inaccurate image on others.

What Can Be Done?

If these ideas are correct, what can we do about it? Theoretically the answer is simple. Get to know each student so well that you can understand how he feels, and so you can understand wherein lie his inaccurate subconscious images; and then patiently and without threat set him on the right track each time his behavior shows that his perceptions are inaccurate. But this is a large order. In the first place, it requires knowing more about a student than he knows about himself. It also requires more individual attention than we can afford in our present educational system. Finally, if we are honest, we must admit that we teachers, as human beings, may have some inaccurate subconscious perceptions ourselves. No private images of ours can be generalized to the students, if we are to help them with their perceptions. As teachers we should examine our perceptions of the students as objectively as possible. We must be free of any subconscious images of students as being immature, stupid, or lazy.

Let us assume that we are "secure in our own perceptions," and therefore that we can be objective enough to be of help. Admitting the impossibility of extensive individual contacts, I would like to suggest that we can apply these principles in our day-by-day dealings with students. We have boiled them down to the following: a student may have subconscious perceptions of the teacher, of himself, or both, which are grossly inaccurate. The question is, can we recognize a distorted image, and if so can we change it? As far as recognition goes, much can be done by observing the subtleties of a student's behavior; by noting when his behavior looks unreasonable to us and then asking ourselves what perceptions might have led to that behavior. I have illustrated this with several of my examples.

Now let us consider what we can do in a situation where the student does have distorted images that need changing. First, and probably most important, he must be accepted as he is, distorted perceptions and all. We do not tell him directly our evaluation of him; he would not believe it. His distorted image will dissolve only through the steady action of day-by-day offerings of evidence from someone with whom he feels comfortable and whom he respects. The moment he is rejected he is again sure that his distorted image is correct, and the distortion is reinforced.

I have one specific suggestion. We

could begin by emphasizing that as teachers we are the students' employees, and that in the discharge of our duties it will be necessary to give certain assignments, and to administer examinations, etc. Many of you may have tried something like this, and may claim that it does not work. I agree that this alone will not work; it is just a start. From my own experience, it seems that it will not work unless it is followed by months of action on the part of the teacher, which action demonstrates uniform adherence to the stated principle. In other words, the teacher has to thoroughly believe it, and live it. I will illustrate what I mean. Suppose I, as a teacher, point out the above principle at the beginning of the term. Later on a student is delinquent and I say to him "I told you this assignment was for your own good; why didn't you do it?" As soon as I say that, the student feels rejected, and he is no longer perceiving the neglected work and formulating a plan to deal with it. Instead, he may perceive the need to defend himself. In fact, it may sound so much like being told as a child that he was being punished for his own good that his response will be patterned after the immature earlier childish response.

Now let us try another response. Suppose I say "I see you were unable to get that work done, could I be of help to you?" Or perhaps, if there is no time to give help, I could say "I see you were unable to get that work done. I understand how it is sometimes difficult to get things done, but of course you realize I cannot give you full credit, because it is late. I am sorry." I think you can see that there is much less threat to the student in either of the last two statements. A slight difference in wording can make a big difference in the amount of acceptance felt by the student. As another example, consider the two replies "don't let it happen again" and "I hope it won't happen again." The first statement rejects the student; whereas the second one accepts him.

Possibly you may feel that I am blowing this up to unreasonable proportion; that a student could not be profoundly affected by such minute distinctions. I would agree that a single teacher response, one way or another, may not make much difference. It is the cumulative effect of dozens or hundreds of them that can be important. If the component is always in the direction of acceptance, the effect will be cumulative. It is like an errosion process.

You will recall that I said the teacher has to live according to these principles. He does not have much time to think out the responses, although at first it may be necessary to do so. After a while they can become automatic, but until then a wrong one may sometimes slip out. I will plead guilty to having made many mistakes. Once, when a student missed something on a quiz which had been explained just the day before in class, I said "you should have gotten that; I just explained it yesterday. See how simple it is." How much more helpful it would have been to have said "It's too bad you missed that; I understand how easy it is sometimes for the simplest things to evade us."

Acceptance of the student by the teacher is the corner stone of the suggested procedure. If a student fails to get his work done there is a reason which is very valid to him, even though to the teacher it might superficially appear to be sheer laziness. This we must accept. Maybe at a later time the cause will have disappeared, but at the time it is with the student we cannot shame him away from it.

I have one more important observation to make. Earlier I spoke about how we might determine whether a student has misperceptions that are disturbing him. Now that we have considered what sort of treatment to give, we see that it would not hurt anyone. Therefore, it is not so important to be sure which of the students need help. All members of the class can be treated with acceptance, and

the students will draw from their experience and contacts with the teacher to the extent of their needs. However, this would be a minimum program. Specific inaccurate perceptions of individual students should be heeded whenever recognized.

I think by now I have given you enough examples to show you what I mean. If, in the day-by-day contacts you really accept the student as he is, and act in terms of his needs, which means doing your best to learn what are the incorrect perceptions to which he is reacting, then, as the weeks pass, he may gradually readjust his image of you, and he will finally believe what you said when you said that you were his employee, working for him.

A somewhat oversimplified, but useful, concept of what I have been talking about is to say that it is a method for reducing the "effective" size of the class. We all know that teaching is more effective in small classes. No small part of this is probably due to the close relationship between student and teacher in a small class, which permits these desirable sharpenings of perceptions to take place automatically. Thus, in a sense, I am suggesting that we can improve teaching in a large class by "artificially" generating some of the conditions which naturally prevail in a small class.

Based on Theory

For the most part you have noted that my recommendations are based on a theory. I have not presented objectively evaluated experimental evidence in support of this theory; but subjective evidence obtained so far is encouraging. I would like to cite one recent case which I think is significant because the student in question was rather typical. At the beginning of the term this student was mainly interested in impressing me. He had a slight acquaintance with the subject, and he liked to flaunt it by asking irrelevant questions on advanced work. The first quiz showed very little grasp of the subject; he apparently did not want to bother with fundamentals. I suspected that he perceived a teacher as someone to impress, and this was the cue to my response to him. I received him warmly, and within myself accepted him as he was. I liked him. However, I avoided giving him support in his attempts to impress me, and repeatedly tried to direct his attention to the subject matter of the course. During the course of the term the change in his behavior was very marked, but it occurred slowly. No change was apparent in the first month, but gradually his questions became more pertinent, and less frequent. His work improved. He moved from near the bottom of the class to better than average by the end of the term. Of course, I must admit that this is a subjective evaluation, and there is no certainty that the results were due to my method of handling the case. However, it seems that the number of successes of this sort has increased since I have modified my classroom responses. It is my hope that objectively evaluated experiments may someday be carried out which will test these ideas more accurately.

Summary

In closing, I would like to summarize the main points of this thesis. Every student is an individual who probably has some distorted perceptions relating to the learning situation. These distorted perceptions lead to ineffective behavior, because he responds to these subconscious perceptions, rather than to the job of learning. The teacher can be helpful by recognizing these possibilities, always attempting to behave toward the student in such a way as to improve the accuracy of his perceptions. In order to have this sort of effect on the student it is necessary that he be treated in a warm and accepting manner. As used here the word "accepting" means accepting recognition of the student and his distorted attitudes; recognition that his behavior is strongly influenced by these attitudes, and

that they will change slowly if all. It does not mean coddling the student. I am not recommending a "soft" attitude in the sense that such an attitude would remove requirements and give the student free reign to do as he pleases. Work demands on the student can be as rigid as desired, within limits of possible accomplishment; but the above principles governing behavior toward the student can be applied within whatever administrative structure is used. For example, penalties can be involved for late work, but they should not be accompanied by inappropriate remarks.

Finally, I would like to say that anyone trying these ideas would do well to arrange to have one or more collegues working along the same lines, so that problems that arise can be freely and frankly discussed in periodic staff discussions. This can help to bring out some of the subtleties which will not be apparent from my words alone, and it will also help you to inspect your own perceptions and possibly to make them more accurate. To the extent this is done the more automatically will appropriate responses come to mind when dealing with students. In other words, what I am saying is that one of the most effective ways for a teacher to learn this type of behavior is for him to participate in group discussions with others, so that he may continually reorient himself in the light of insight gained as he reacts to his colleagues and to himself as he recites his experiences.

College Notes

A department of metallurgical engineering has been established in the **New York University** College of Engineering. Acting chairman of the new department will be Dr. John P. Nielsen.

A Motion and Time Study Intensive Course, offered by the Department of Industrial Engineering of **Washington University** at St. Louis, will be presented from June 8th through June 17th. This course is intended for personnel desiring a basic introduction to Motion and Time Study. Material covered will be presented with emphasis on setting up correct methods before work is in existence as well as techniques for the improvement of existing methods and procedures. The objectives of the course will be to prepare the attendee to (1) apply Motion and Time Study in his own organization and (2) train others in his company in the principles of Motion and Time Study.

Several visiting speakers will present their experiences with the application of Motion and Time Study and with related fields in industry to further enhance the material of the course. The course is under the direction of Dr. Gerald Nadler of the Department of Industrial Engineering at Washington University. Other members of the intensive course teaching staff include industrial personnel as well as university faculty.

This course is being presented with the cooperation of the St. Louis Chapters of the American Institute of Industrial Engineers and the Society for Advancement of Management. For further information concerning course content, instructors, and registration, write to the Department of Industrial Engineering, Washington University, St. Louis 5, Missouri.

The appointment of Karl B. McEachron, Jr. as Dean of the Undergraduate School of **Case Institute of Technology** effective on June 1, 1955, has been announced. Dean McEachron will assume a portion of the duties now held by Dr. Elmer Hutchisson who has been Dean of the Faculty at Case since 1945. Dean Hutchisson will devote his full time to his duties as Dean of the Graduate School and Director of Research on June 1, 1955.

Report of the ECAC Military Affairs Committee on the Study of ROTC Curricula in Engineering Colleges

Fall 1954

Submitted by

ELMER C. EASTON, *Chairman*

At the request of the Evaluation Committee of A.S.E.E. and other interested groups, the Military Affairs Committee of the Engineering College Administrative Council prepared and circulated an ROTC Questionnaire consisting of three parts. The covering letter explaining the questionnaire is shown as Exhibit 1 of this report. The questionnaire forms are illustrated in Exhibits 2, 3, and 4 where the summaries of the replies are given.

Questionnaires were mailed to 145 engineering colleges on September 27, 1954. By November 1, 1954, when the results were analyzed, 89 usable replies had been received.

Part A of the questionnaire was used to determine current practice with regard to the granting of credit for ROTC courses. The replies showed that the Army General, Air Force General, Combat, and Specialized programs are handled in a fairly uniform manner. The credits allowed in the Navy sequence are slightly different.

Almost all of the colleges offering Navy ROTC programs have 12 credits of basic and 12 of advanced courses in the ROTC sequence. Approximately 10 per cent of the colleges allow no ROTC credit toward the B.S. degree in engineering. The averages allowed (counting all colleges) are 8.0 credits for the basic courses and 9.6 credits for the advanced courses. Approximately 57 per cent of the colleges do not permit advanced ROTC degree credits to be substituted for engineering courses. The average permitted (counting all colleges) is 2.8 credits. Approximately 24

TABLE 1

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR ENGINEERING COURSES (NAVY ROTC)

Number Inst.	Credit Hours
12	0
1	1
2	3
3	6
1	10
2	12
(Total 21)	(Average 2.8)

TABLE 2

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR HUMANISTIC-SOCIAL COURSES (NAVY ROTC)

Number Inst.	Credit Hours
5	0
1	1
5	6
3	9
7	12
(Total 21)	(Average 6.66)

TABLE 3

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR ENGINEERING COURSES

Army General		Air Force General		Combat		Specialized	
No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.
21	0	33	0	14	0	20	0
2	1	5	3	1	3	1	3
3	3	10	6	1	4	1	4
4	6	1	8	3	6	5	6
1	9	1	10	2	12	1	9
2	12	5	12	(Total)	(Average)	1	10
(Total)	(Average)	(Total)	(Average)	(21)	(2.33)	2	12
(33)	(2.06)	(55)	(2.78)			(Total)	(Average)
						(31)	(2.58)

per cent of the institutions do not permit the substitution of advanced ROTC degree credits for humanistic-social courses. The average allowed (counting all colleges) is 6.66 credits. The variation in practice with regard to the last two items is shown in Table 1 and Table 2.

Among those institutions offering Army General, Air Force General, Combat, or Specialized ROTC programs, approximately half have a basic ROTC sequence of 4 credits, while the others have a basic program of 8 credits or more. The average is approximately 6.25. Most of the colleges have 12 credits in the advanced sequence. The average is almost exactly 12. About 11 per cent of the colleges allow no ROTC credit toward the B.S. degree in engineering. The averages allowed (counting all colleges) are approximately 5.2 credits for the basic courses and 9.05 credits for the advanced courses. Approximately 63 per cent of the colleges do not permit advanced ROTC degree

TABLE 4

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR HUMANISTIC-SOCIAL COURSES

Army General		Air Force General		Combat		Specialized	
No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.
8	0	12	0	5	0	9	0
1	1	1	1	1	3	1	3
1	3	2	3	4	6	7	6
3	4	2	4	1	9	3	9
9	6	21	6	9	12	10	12
2	8	1	8	1	14	1	14
2	9	4	9	(Total)	(Average)	(Total)	(Average)
6	12	11	12	(21)	(7.53)	(31)	(6.65)
1	16	1	16				
(Total)	(Average)	(Total)	(Average)				
(33)	(5.8)	(55)	(6.05)				

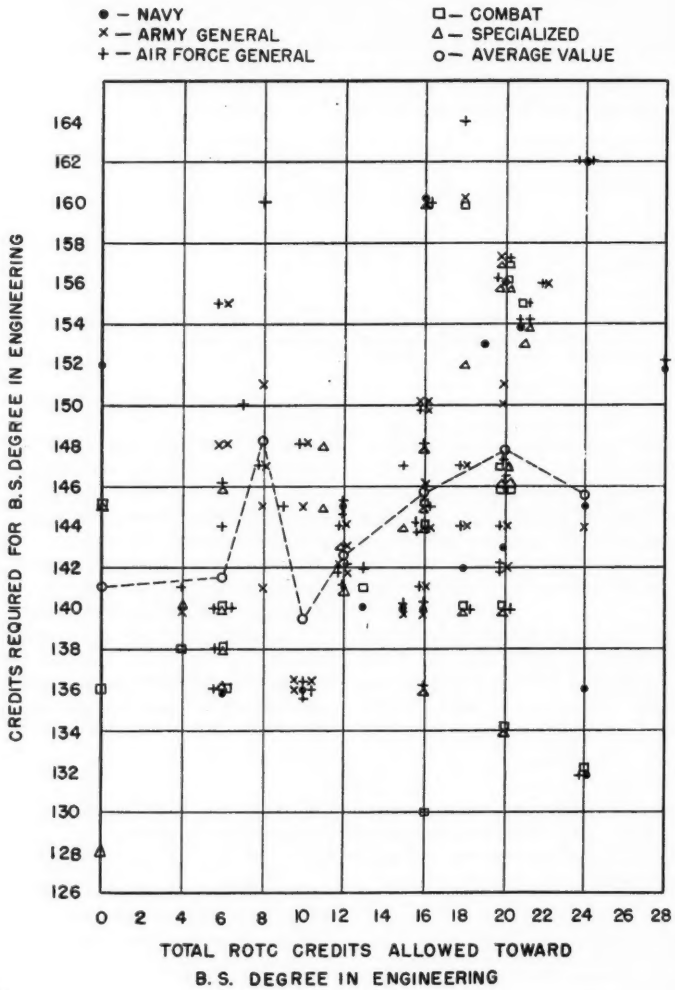

FIGURE 1.

credits to be substituted for engineering courses. The average permitted (counting all colleges) is approximately 2.48 credits. Approximately 24 per cent of the institutions do not permit the substitution of advanced ROTC degree credits for humanistic-social courses. The average allowed (counting all colleges) is approximately 6.3 credits. The variation in practice with regard to the last two items is shown in Table 3 and Table 4.

Figure 1 illustrates the relation between the total ROTC credits allowed toward the B.S. degree in engineering

(Column 6 of Part A of the questionnaire) and the total number of credits required for the degree. It is obvious that there is no uniformity of practice. The average number of credits required for the B.S. degree appears to rise in an erratic manner from about 141 in those colleges which allow no ROTC credits to be used toward the degree to about 146 in those institutions which allow 24 ROTC credits to be used toward the degree. Undoubtedly, some institutions treat the ROTC credits as additions to a basic program of other subjects. In these colleges the total credits required for the degree is substantially higher than it might be if the ROTC program were not available to the student. On the other hand, it is clear that some colleges have a low total requirement for the degree despite a high permissible ROTC content.

TABLE 5

PERCENTAGE OF ADVANCED ROTC SEQUENCE JUDGED TO HAVE CONTENT COMPARABLE TO ENGINEERING AND HUMANISTIC-SOCIAL COURSES OF COLLEGE LEVEL

Navy	59.9%
Army General	47.3%
Air Force General	49.0%
Combat	42.2%
Specialized	45.7%

The answers to Part B of the questionnaire indicate that the percentage of the Advanced ROTC sequence judged to have content comparable to engineering and humanistic-social courses of college level varies as shown in Table 5. A further breakdown is given in Exhibit 3.

When answering Part C of the questionnaire, those institutions which have converted from a specialized Army Branch Program to Army General Military Science indicated that the new program is at least as good as, and in some respects better than, the old. Very few indicated that the new program was poorer than the old. The distribution of replies is shown in Exhibit 4.

The members of the Military Affairs Committee who participated in this study are David L. Arm, Jess H. Davis, Paul E. Hemke, Lee H. Johnson, John H. Lampe, J. F. Downie Smith, Harold E. Wessman, Elmer C. Easton, Chairman.

EXHIBIT 1

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL

MILITARY AFFAIRS COMMITTEE

September 27, 1954

To All Deans of Engineering.

Gentlemen:

There appears to be need for reliable information regarding (1) the amount of credit being granted for ROTC courses, and (2) the opinion of engineering educators concerning the educational value of the advanced ROTC courses. The Military Affairs Committee of E.C.A.C. has been asked to obtain this information. Accordingly, the enclosed questionnaire is being sent to you with the request that you please fill it out and return it not later than October 23, 1954. A copy of the summary of the answers will be sent to all who reply.

Part A of the questionnaire refers to credit granted for ROTC courses. If the allowable credit differs among various engineering curricula, please show the range of values in the table.

Part B concerns the evaluation of the course content of the *advanced* ROTC courses. Please indicate the percentage of the total advanced ROTC program which, in your opinion, is equivalent to (1) humanistic-social courses of the college level, (2) engineering courses, (3) vocational training, (4) extra-curricular activities. For example, if you believe that one-quarter of the advanced program has educational content similar to that gained through participation in extra-curricular activities, place the number 25 in column 4. When

answering Part B, please give the evaluation as you think it *should* be, not necessarily as it is at your institution.

Part C has been included partly to aid the Engineering Manpower Commission Sub-committee on the Branch General Program and to obviate the necessity for a separate questionnaire from that group.

If you have any questions regarding interpretation of the questionnaire, please write write to me for clarification before completing the form.

Sincerely yours,

ELMER C. EASTON
Chairman, Military
Affairs Committee

College of Engineering
Rutgers University
New Brunswick, N. J.

EXHIBIT 2

SUMMARY OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART A

Fall 1954

Credit Allowed for ROTC Courses

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

Type of ROTC Program	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Replies
	Total credits* in ROTC sequence			ROTC credits* allowed toward B.S. degree in Engineering			Advanced** ROTC degree credits which may be substituted for		
	Basic	Adv.	Total	Basic	Adv.	Total	Eng'g courses	Hum.-soc. courses	
Navy	12.0	12.0	24.0	8.0	9.6	17.6	2.8	6.66	21
Army General	6.05	12.4	18.45	5.4	8.9	14.3	2.06	5.8	37
Air Force General	6.36	12.4	18.76	5.36	9.06	14.42	2.78	6.05	55
(a)	6.51	11.7	18.21	5.0	9.4	14.4	2.33	7.53	21
(b)	6.55	11.2	17.75	4.87	9.0	13.87	2.58	6.65	31

(a) Any *one* combat branch such as Infantry if offered at your institution. (Replies mostly Infantry.)

(b) Any *one* specialized branch such as Signal Corps. Please insert name of branch. (Replies mostly Engineer Corps.)

* Give credits in semester hours. If you operate on the quarter system, please multilpy by 2/3 to convert quarter hours to semester hours.

** If credit for *Advanced* ROTC is allowed toward the B.S. degree in Engineering, please indicate how many of these credits may be offered as substitutes for engineering courses or humanistic-social courses. For example, if a student may offer x credits of Advanced ROTC in place of either engineering or humanistic-social courses, place x in both columns. If he may offer x credits only in place of humanistic-social courses, place x in the second column and o in the first.

What is the total number of credits required for a B.S. degree in Engineering? *146* Is Basic ROTC required [57] or voluntary [32] in your institution? Is your institution a Land-Grant college? Yes [40] No [49] (89 replies)

EXHIBIT 3

SUMMARY OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART B

Fall 1954

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

Evaluation of Course Content
Two Years of Advanced ROTC

Percentage of work that has content comparable to

(1) humanistic-social courses of college level
(2) engineering courses of college level
(3) vocational training not acceptable for college credit
(4) extra-curricular activities, not usable for college credit

Type of ROTC Program	Hum. Soc. (1) %	Eng. (2) %	Voc. (3) %	Ext. curr. (4) %	Replies
Navy ( )*	24.2	35.7	27.6	12.5	19
Army General	36.1	11.2	30.1	22.6	30
Air Force General	37.0	12.0	27.0	24.0	48
(a)	36.1	6.1	33.1	24.7	13
(b)	21.1	24.6	37.3	17.0	26

* Indicate option such as Line, Marine Corps, Supplys Corps. (Replies mostly Line.)
(a) Any one combat branch such as Infantry. (Replies mostly Infantry.)
(b) Any one specialized branch such as Signal Corps. (Replies mostly Corps of Engineers.)

Was the above evaluation made by the engineering dean [45], another administrative officer [7], or a faculty committee [12]?

EXHIBIT 4

SUMMARIES OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART C

Fall 1954

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

If you have converted from a specialized Army Branch Program to Army General Military Science, please indicate how the General Military Science Program compares with the former specialized one in the following respects:

(1) In meeting the educational needs of your engineering students—the General Military Science Program is

[14] Better

[13] About the same

[2] Poorer

(29 replies)

(2) In maintaining the interest of your students in the Army ROTC and in influencing them to enrollment in the advanced ROTC—

the General Military Science Program is

11	Better
13	About the Same
4	Poorer

(28 replies)

(3) In terms of interest in the Summer Camp Program first given on a General Military Science basis in 1954—

the General Military Science Program is

11	Better
9	About the Same
3	Poorer

(23 replies)

(4) The Army General Military Science program has replaced the following specialized program(s): *Infantry—21; Engineers—12; Signal Corps—9; Ordnance—6; Quartermaster—4; Artillery—7; Transportation—2.*

Graduate Study in Building Engineering and Construction*

By WERNER H. GUMPERTZ

Assistant Professor of Building Construction, Massachusetts Institute of Technology

The decision as to what shall happen to graduate study in building engineering and construction or any other engineering science depends only partly on us, the educators of today and tomorrow. This battle is being fought right now on the level of kindergarten and between the kindergarten teachers and the parents of the boys who will be our graduate students some sixteen years from now. I recall some sessions that I had as a member of the faculty of the Bridgeport Engineering Institute where the humanities instructor was at the same time a teacher of English in the local high school. All of the other instructors gleefully descended upon him and criticized him for the poor preparation that our students had received in English. To our surprise he immediately passed the blame on to the grade school teachers and advised us that we would not find the culprits there either, that the culprits were to be found on lower level, the kindergarten. The kindergarten teachers in turn were blaming it all on the parents.

Before I start trying to make a definition of what graduate study in architectural engineering is and what it means, I think I owe you an explanation as to why I think that this battle will be fought in the kindergarten. The sad fact is, and one that most of you are only too familiar with, that the standards of primary and secondary education are being reduced to an ever increasing degree. It seems to be our policy that the only way to improve education is to broaden the base ever more and to give an academic type of education to every last boy and girl in this country regardless of whether he or she is qualified, or even interested in receiving this education. Obviously, it is impossible to keep any kind of standard if such a policy is to be followed. Of course every boy and girl should have an opportunity to get the education for which he or she is best suited, regardless of social or monetary standing. However I believe that if we want to check the trend toward ever broadening and flattening academic education, we must admit that the same type of education is not for everybody.

You need not be told how little preparation there is right now in English, report writing, speaking and spelling, not to talk about such complicated matters as arithmetic, algebra and trigonometry. Our high schools nowadays give the student an extremely wide choice of subjects, and some of the basic disciplines are not among the required subjects. On the other hand, a lot of new courses are available to the student who is interested in them, such as home economics, creative dancing, sex education in three easy lessons, and credits given for personal hygiene. Now the worst of the results of such a policy of trying to give everybody exactly what he thinks he wants and paying no attention at all to a proper development of the young mind, is not the ignorance that we so woefully find in our freshmen in colleges. The greatest trouble is that these young minds are

* Presented at the Architectural Engineering Division, ASEE Meeting, University of Illinois, June 17, 1954.

never required to seriously fight with an intellectual problem. Everything is made easy for them, such as alternate solutions, true and false questions and escapes of many other sorts. Now in the middle ages in Europe there was a mythical device called the funnel of Nuremberg; this funnel was a wonderful invention. It could be placed into a hole which had been judiciously drilled into a student's skull, and wisdom and knowledge could be poured into that funnel and into the pupil's brain by the quartful if not the gallonful. It was a painless or a king's way to learning. Unfortunately, the recipe to this wonderful process has been lost since and we will have to deal with the problems of learning in a more prosaic way. There is no doubt about the necessity of instilling into young minds a mental discipline which faces them with the unpleasant facts that in order to learn you must work, and if you want to achieve something, it takes effort and pain to do so. There is no better satisfaction than having been able to achieve something through hard work. Now while luckily learning by rote has gone out of the window and I hope forever, there are many ways in which the basic human values, the humanities, the common heritage of thousands of years of human culture must be given to our children as well as the result of thousands of years of ever increasing achievement in the sciences. This is, of course, primarily a problem for the elementary and high school teacher; however, we must be quite aware of it because we are getting the results of that primary and secondary education.

Direct Bearing on Graduate Study

The reason why I am bringing this up at length is because this has a direct bearing on graduate study. The question has come up recently more and more often exactly what graduate study is supposed to accomplish. In order to make a competent professional man these days takes more rather than less knowledge, and there is no miracle yet with which we can increase the amount of learning that we can give these men in four years. Unfortunately, many educators are thinking about the easy way out, that of adding a fifth or sometimes a sixth year to the engineering curriculum. Others try a solution in a very similar way by making a liberal arts course a prerequisite for engineering school such as is now the case with medical education. There is no excuse for this. I feel that high school should teach such things as the handling of one's native tongue, maybe one or two foreign languages, an ability to deal with ideas, and a cultural heritage enabling one to be more than just a slide-rule engineer.

Men are becoming older and older by the time that they have prepared themselves for a professional career. It was not so long ago when a bachelor of science degree was sufficient for a successful career in any field of engineering, including the academic field. We all know that this is no longer the case. By the time you are a Ph.D. or Sc.D. you are probably twenty-eight years of age and you probably have to work for a few more years until you finally can take over the responsibilities that go with having a family. This is morally and socially a questionable situation. A young man is physically ready to be married when he is seventeen. He probably is emotionally ready when he is twenty-three. If we make this young man dependent upon his family and unable to respectably get married and support his family as it has been the custom for untold thousands of years, we are committing a crime on that generation. There is absolutely no excuse for keeping the student in school for such a length of time simply because we fail to give him the education that he is entitled to in the first place. For the intelligent general practitioner of engineering, a bachelor's degree should give a full and proper preparation so that he will be enabled, after due experience, to become a useful and creative member of his profession,

without being required to be ashamed of the fact that he has no higher degree. Graduate study should be reserved for serious specialization in a technical field. It should not be simply an extension of more and more involved undergraduate courses. Instead it should have a very definite goal towards a professional education which is usually described as a desire to go into research, development, or teaching.

This raises the necessity for reviewing our attitude towards the way in which graduate school is being taught. A lot of devices which are quite useful in connection with undergraduate courses, are mechanistically applied to the graduate school as well, and I think that it would be very useful to review this situation from the bottom up. I would evaluate every teaching technique, device and administrative organization which is used to educate our young men toward the M.S., Ph.D., or similar degrees. Our emphasis should be in a different direction. For instance the responsibility of the mature student to actively plan his own curriculum and to be responsible for his own actions without being spoon-fed cannot be escaped, if you truly want to give the student the highest education. This probably means that to a large extent the students themselves should plan features of courses of instruction in various disciplines, and should be their own masters as to how they use their time to a much larger extent than they are now. There are definitely dangers in this procedure, because a weak character might very well take the easy way out, select a "snap" subject to write a report on, or to delay the assignment until the last minute, when it cannot be done to the satisfaction of the instructor. The student should, therefore, together with this new liberty, be willing to accept the responsibility to stand or fall with the things he himself is doing in graduate school.

There is further need for us, as educators, to review carefully every subject that we are teaching in graduate school, and to evaluate its contribution. Since it is obviously impossible to teach a man everything about his profession, and since it is probably even more ridiculous to teach him more and more about less and less, until he knows everything about nothing, we cannot equip him to deal with every situation that he will encounter, simply by telling him the solution of all possible problems. The only efficient alternative is to develop in the graduate student a mental discipline and a mental approach to problems which, together with his basic training in his graduate studies, will enable him to approach successfully any problem he may encounter.

Need For More Basic Theory and Research

Looking at the problem from the standpoint of the building industry, we must ask ourselves what the most important possible contribution of the college trained, and especially of the engineer with an advanced degree can be. It seems that despite its size and importance, the construction industry is not too progressive in regard to research. Most achievements in this field have been accomplished by a few lone individuals, who have sometimes worked on the principle of trial and error. Compared to such other fields as medicine, agriculture, chemistry, business administration and pharmacology, the progress in our own field has been rather hectic, disorganized and more or less accidental. Most of our competent contractors, who know how to put up a workable building, do not know exactly why their methods will work. Yet they work sometimes better than the architect's idea. The architect might have noble ideas, but he is sometimes without the necessary experience to choose the correct materials and the combination thereof to obtain a workable building. I was recently retained by a client who had a house built for him by an experienced builder. One foundation wall of that house had collapsed three different times,

and each time rebuilt by the builder. In each instance the builder failed to realize some of the most elementary facts of engineering. If such experienced man could commit a foolish step three times without gaining an understanding of what was wrong, I wonder how the whole industry can ever progress efficiently without having a much more serious approach to basic theoretical principles and a broader acquaintance with all aspects of building. Building engineers cannot be onesided and be satisfied only with utilizing existing materials, with adding a new twist to the design of structures, or with figuring out a better way of handling the construction job. They must be well trained to understand the interrelationship of these various aspects. I feel, therefore, that our most important contribution can be to change the haphazard approach to the problems of the building industry to a more systematic one, and to train a new generation of building engineers who can approach the problem from a mature and well rounded viewpoint which goes far beyond the ability to analyze. Their task is to synthesize.

Synthesis Needed for Professional Achievement

The most important task is to wipe out the many lines of division separating the various disciplines from each other. I have found that even among the undergraduates the lack of synthesis of the many courses of instruction is painful, and often felt so by the students. In case of a graduate student there is even more need to create a whole out of parts. The number of graduate students in our department is small enough that we can make arrangements to combine certain classes. Seminars can help to understand the problems that are faced by the industry, and which cannot be compartmentized the way that a college catalogue might be compartmentized.

This synthesis becomes of even greater importance when we realize that ours is not an exact science, and that we must be in constant touch with the field. To me this means among other things, that the instructor himself must be engaged in a certain amount of consulting to bring ever new problems to pose, and to get ever new solutions to fertilize his own thinking, and that of his students. However, sometimes this might not be possible, or the instructor's consulting work might be too specialized to be of direct use to the students.

In such situations, the use of outside speakers might be considered. As an example, I should like to refer to my experience with a course in building management. This course is designed to train graduate students in the management of existing buildings with all its aspects; the knowledge of structural engineering and construction methods and construction management is a prerequisite. As can be expected, no useful text has so far been found which fits exactly for such a course. Our sources are taken from law, business management, books on engineering valuation, courses of real estate management, labor relations, and insurance manuals. Since it is impossible for the instructor to be an expert in all of these fields, I thought it best to invite men from the field to address the students. One of the leading appraisal engineers fortunately volunteered his services for this course and he gave an excellent course of instruction in engineering valuation. He used a building which he was in the process of evaluating as an example, and had the students work out the problem independently of his own studies. To our delight we found that the students had produced a good looking and mature paper, the findings of which were checked by the engineer himself and found to be very similar to his own. This showed not only that the students had learned a lot from this approach, but also that they could be trusted to produce an efficient piece of work under actual conditions with practically no supervision. This would have been impossible without going to the building in question and having a long and interesting bull session on the

various aspects of land taking. Problems of foundation and structural engineering also had to be considered. The result was a paper containing essential ingredients from several distinct but related disciplines.

Other lecturers in this course included real estate men who discussed problems of managing the different types of real estate, each one with which the speaker himself was familiar. Maintenance engineers of several organizations such as schools and department stores lectured on their specialty, the secretary-treasurer of the local building maintenance union of the A. F. of L. discussed labor problems, and several instructors from the M.I.T. Department of Economics dealt with problems of the general national economy, pricing and financing. The remaining hours were utilized to correlate the information that the students had received from the guest speakers and to make sure that one organic whole was the result. Various papers were written by the students, utilizing the information thus gained. The students had only the most elementary guidance in writing these papers, as if they were consulting engineers, i.e., without outside help. This confidence in the students has been amply repaid with intelligent and interesting papers.

Using outside speakers is a highly promising but at the same time dangerous procedure. I have found time and again that men who had achieved stature in their own field in building construction, who were excellent men to talk with, who had intelligent ideas, froze up as soon as they came to the class because they were over-awed at lecturing at a technical institution. They felt called upon to be highly formal, to be as "theoretical" as possible. Consequently the primary purpose of their coming, that of giving the benefit of their composite experience, was sometimes lost in this formality. It has been difficult to get these men not to worry about a polished lecture, but rather to bring the realities of professional practice into the classroom. However, using about 70 per cent outside professionals and about 30 per cent faculty from other disciplines, I feel that there has resulted the nucleus of a workable course that is realistic to the students and which brings the various points of view. I myself have learned a great deal from hearing experts in the various fields. This year I wrote a full set of class notes, using student papers and my own notes taken during the guest lecturer's hours, and added some of my own ideas to it. I am citing this as an example of how a text can be fashioned from independent work of students and from information given by outside speakers.

Professor Voss, the former head of this department, is at this moment writing a paper which will eventually become a book on advanced construction management. He himself is using his very extensive knowledge of the building construction field to enumerate for class notes (and later on for a book) the things which are usually passed on only informally, and very often inadequately, in construction firms', and engineers' and architects' offices. I, therefore, have high hopes that this synthetic approach will eventually produce a set of class notes which will be truly useful for graduate study.

Course Content

I shall try to summarize some of the thoughts that come into my head regarding how a successful graduate study should be separate and distinct from similar undergraduate courses. Needless to say, the course content itself should be on a higher plane and more difficult. There should be a minimum of help to the students, and their success and failure should depend primarily on their own initiative and ability. As far as possible, a larger latitude should be given to the students in choosing the subjects to be discussed. There are both experienced and inexperienced students, and the

instructor should be flexible to a reasonable degree, to allow the substitution of certain subjects for others if this seems to be more useful. Sometimes the problem of varied experience in the students' background can be solved by giving different assignments.

As to the specific conduct of the classes themselves, here are my ideas of how the problem could be approached:

(1) *Preparation.* Each graduate student should have sufficient preparation in the undergraduate subjects to be able to handle the graduate subjects without any trouble. At times this will mean that a man who has received his degree from another institution will be required to take a great number of undergraduate subjects, including those of the sophomore and junior years. While this might be unpleasant for the graduate student, it is more useful to him in the long run to catch up on the prerequisites on which the graduate courses of study have been based.

(2) *Examinations.* In graduate school the usefulness of quizzes is dubious. Every year I go through the mechanics of giving my graduate students quizzes, although our classes usually include less than six, or at the most ten students. I have yet to find a case where any written examinations have modified the original impression I received about the student, based on his performance in class and from the papers he was required to write. One of the reasons why we do require quizzes is that M.I.T. still works on an arithmetical grade system, including cumulative ratings. This method incidentally is now under attack on the undergraduate level, and a faculty committee is considering a proposal to drop the cumulative rating of students, because it makes the students too competitive without achieving any serious educational purpose. I myself am wistfully hoping that in the not-too-distant future the graduate school will drop requirements for quizzes and grades entirely, and will be satisfied with a composite judgment of the various instructors as to whether a certain graduate student has achieved his goal or not. This is undoubtedly a more difficult thing to achieve than our present grading system; however, I believe that much better judgment can be reached by such conference methods and by a more thorough evaluation of the individual's capabilities in all fields combined. Note here, however, that I do not believe that we should lower our standards in any way; on the contrary, I think that the work of the student (as it must be evidenced in other ways) should be severely evaluated in order to make sure at all times that it is of graduate caliber.

(3) *Reports.* For this reason, reports are in my opinion the heart of the student's work in class. Such reports should be preferably of the student's own choosing in content, and should, of course, be related intimately to some phase of the subject which is being taught in the particular course. The student should be expected, after an initial conference with the instructor, to carry through his paper by himself, and regardless of whether it is a library or field study, he should use his own resources in order to obtain the necessary information and correlate it in his own way. Once the student turns in his report, he should be required to address the class and tell of some of the essential findings of his report. This means not only that the class as a whole gains the advantage of the additional information, but that it teaches the student to relate himself to other people. Thus he learns not only the information contained in the paper, but that it is almost equally important to be able to transmit ideas to other people.

(4) *Seminars.* The natural outgrowth of this type of paper is the seminar type course. I now have plans for a new seminar in construction management which will start next spring. We hope here to obtain as guests some of the leading men in the construction industry and related fields in this area. The seminar will probably take place at least partially at night, in order to enable the various outside men to attend these meetings

without difficulty and without having to cancel their appearance because of other commitments. There will be no fixed curriculum and the students themselves are expected to contribute a major part to the success of the seminar. Discussions alone are projected and no formal addresses are expected to be made by anybody. This will, I hope, involve each student intimately with the problem itself and with the men who have been handling these problems successfully for years. In some of the meetings the students will be expected to organize the meeting itself and to contribute enough useful information to make this meeting worth while. In such cases some of the outside men will be used as arbiters or evaluators to tell the students and myself whether our contribution has been a positive one. The participation of this type will not only be useful for the students but it almost certainly must contribute heavily to the judgment of the instructor in arriving at a decision as to whether each individual student has reached the goal of the course.

(5) *Coordination with other courses.* In the coordination with other courses we probably have not done as much as would be desirable. It is readily understood that problems of instructors' schedules and meeting times are still formidable. However, I hope that with time we will be able to work out a system where the instructors of the various disciplines such as materials, structural engineering and construction methods will be able to give joint classes so that the students will be in a position to see how all the disconnected pieces of information that they have acquired for years are carefully put together by professionals. This is the one thing which we do not teach in undergraduate school and the one thing which I believe would be most useful for the graduate student. After all, when an engineer graduates, after a few years of experience he will have to do just that—combine his knowledge in many fields—and since we are in the fortunate position of having experts in so many different fields, the natural consequence would be to utilize the combined knowledge of these men in one combined meeting with the students.

(6) *Case method.* The next natural step is to the case method itself. Enough has been said in the *Journal of Engineering Education* about the case method to give it serious attention. However, the compartmentization of all courses of instruction so far has made the application of the case method somewhat difficult. However, the few feeble attempts that I have made in the direction of the case method approach have given me hope that such an approach would be very fruitful to graduate students.

This certainly includes outside work. I have mentioned the example of how a valuation engineer took our class to a building which had to be evaluated because of a land taking by the Commonwealth of Massachusetts. I can think of a number of similar situations where actual problems are at stake. Such problems could be dealt with by students, utilizing their knowledge in the various fields of study. The advantage of such a procedure is obvious. The students will gain an increased sense of reality from their work, and therefore a tremendous incentive toward creativity. We will also have a built-in means of checking the students' work by comparing it with the activities of the professionals who are actually engaged in working out the solution for such projects.

Conclusion

Graduate study in architectural engineering will soon some to the proverbial crossroads. Unless checked, the desire of some educators to extend undergraduate study for another year or two, or to convert engineering school into a postgraduate school may be attained. We will then find that our present system of graduate education will become just another version of undergraduate study and a requirement for a professional career. Instead,

graduate study should be reserved for those men who want to go beyond the preparation for a successful professional career. These are the men who are destined to spark the progress of our profession in its many fields.

Once we realize the necessity of keeping professional graduate education apart from undergraduate education, we should start thinking about the type of teaching that we want to do in graduate school. I believe that we should give up most of the formal requirements for graduate study. Quizzes are unsuitable to test fairly a man's ability for creative work. We should develop the best constructive ability in graduate students by encouraging them to use their own initiative, and by providing them with the best background and best information possible. We can do no less to equip our graduates for a creative life.

College Notes

The **University of Hawaii** Engineering Department has completed the installation of test equipment consisting of a pair of steam-turboelectric generators. The normal rating of each turbine is 25 KUA with an overload rating of 31 KUA each. Steam conditions are 125 PSIG saturated steam at the throttle and 2 to 5 inches Hg at the exhaust. Crossover steam pressure is 50 PSIG when the turbines are operating in series. The Westinghouse Electric Corporation, the United States Navy, and a number of Honolulu industrial companies assisted the University with both material and volunteer services in installing this equipment.

The Role of the Case Method in Engineering and Business Education*

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The so-called Harvard "case method" was developed as a device to induce students to learn by simulating actual experiences, as distinguished from purely memorizing rules and principles.

A case is a description of real situations which must be faced by the engineer or business executive. It brings to the class room a device for placing the student into situations where, as an administrator, he must recognize existing problems, evaluate the evidence, and act with responsibility.

No predetermined answers are available to him; but through the study of a variety of specific cases involving actual company situations, the student is exposed to the types of problems he is likely to face in his later industrial experience.

With the text book method of teaching, the tendency is to memorize various terms and solutions, whereas study by the case method demands continual *use* of terms and methods of analysis to the point that they become automatic. Generalizations developed from cases do not automatically afford answers to new problems which have a way of not being "typical"; but learning how to differentiate one situation from another, and how to recognize the more important issues, contributes to the development of analytical and administrative capacity. Thus through a series of such experiences, the student absorbs a background of factual information, methods of attack, rules of procedure, and principles, for guidance in changing sets of circumstances.

Challenge and Incentive

The case method places the student into a situation where he is faced with a problem to be solved and with a course of action to be recommended. The responsibility for solutions is placed upon the student rather than upon the instructor. This challenge to the student's ingenuity is a far more potent and palatable incentive than regimented reading assignments and memorization of specific principles, formulas, and busy-work routines.

Early Frustration

During the early stages of case study, students usually grasp for some sort of "handle" to help find *the* solution, and often become frustrated when it is discovered that there may be *several* possible solutions. But the training to handle problems to which there is *no one* solution appears to be one of the main benefits of the case method. Through continual discussions in small groups, then throwing their conclusions open for class criticism, students seem to be able to develop appropriate methods of attack. Students report that progress, at first, seems slow; but upon looking back, they are surprised at the rapidity with which they have gained an understanding of the subject.

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Instructor's Role

Successful use of the "case" method apparently requires some techniques that are quite different from those used in typical *lecture* courses, and it often is difficult for a typical "lecturer" to adapt himself to this different role in the class room.

1. The instructor must be a discussion leader instead of a lecturer. He must transfer the center of attention from himself to the students, and withhold his own ideas until they, or other ideas, have been developed by the students. This is particularly difficult for the dynamic instructor with a high degree of ego.

2. He must stimulate the students to develop their own conclusions by asking pertinent questions rather than by suggesting solutions or revealing his own opinions. This places the responsibility upon the students who usually will react to the challenge of statements or proposals from other students, but who will accept, or at least not openly debate, the supposedly expert opinions of the instructor.

3. The instructor must permit and encourage a reasonable amount of free student discussion if it is related to the problem; but he must be alert to re-direct the discussion back to the problem when appropriate.

4. To force participation by, and benefit to, the greatest number of students, questions occasionally must be directed to the "quiet" student.

5. Discussions should be maintained between students, not between a student and the instructor.

6. Successful users of the case method continually emphasize a "program of action." There is a strong tendency for students to propose the first plan that comes to mind, without considering implications or alternatives. When this occurs, the instructor may well ask, "Just *how* are you going to present this plan to the workers? If they won't accept it, then what will you do?" This forces attention upon practical implementation of the proposals.

Learning to Meet New Problems

Learning by the case method is achieved through repeated analysis of varying problems, not necessarily to find solutions to specific problems which may never be repeated, but rather to develop procedures and confidence in attacking new problems. Effective learning is a gradual process, and can not be accomplished by "cramming"; thus it is virtually impossible to review for an examination in a true case type of course. However, proponents of the case method claim that no equally effective method has evolved for compelling a person to meet successively new situations on which he must grapple intellectually with fresh combinations of facts and opinions.

One of the theories of the case method is that the students learn from each other, rather than from the instructor. We might well ask, then, whether one student can learn from another if neither one has had any experience in similar or related situations and therefore knows nothing about the problem. This poses a further question, whether technical knowledge involving basically new material can be learned through the case method alone.

Could We Use the Case Method?

Our Industrial Management Department has the responsibility for Production courses at Northwestern University, both in the School of Commerce and in the Technological Institute. These include: Industrial Organization and Management, Production and Quality Control, Motion and Time Study, Development of Standard Time Data, Manufacturing Problems, Personnel Administration, Personnel Testing and Selecting, Personnel Problems, and several variations and combinations of these subjects. Traditionally we have used the technique of presenting principles and methods through reading assignments, lectures and demonstrations, with each major topic followed by a home

problem involving the application of the principles previously discussed. In our search for alternative and perhaps better methods of helping the students to learn, we visited the Harvard Graduate Business School where the case method is most extensively used. We visited particularly with Franklin E. Folts, author of the well known text, *Introduction to Industrial Management,* which deviates radically from the usual style of Industrial Management text book and is, in fact, a collection of cases in the field of Production. Mr. Folts has been instrumental in, and largely responsible for, the development of the case method as used in the Production sequence at the Harvard Graduate Business School. Our interpretations of his comments are somewhat as follows:

1. Cases are used as a vehicle for lending reality to the existence of industrial problems and the need to find workable solutions.
2. The cases are carefully selected and prepared, always keeping in mind the overall objectives which are:
   - 2.1 To provide an appreciation of the relationship of production to other operating problems of business, and an awareness of the production aspects of administrative problems.
   - 2.2 To develop familiarity with, and a degree of facility in, the use of certain procedures and techniques that have had their greatest development within the factory and that are rapidly gaining much greater significance as their applicability to other areas becomes more widely recognized; also to develop an appreciation of the limitations of such procedures.
   - 2.3 To develop a degree of self confidence and recognition of personal capabilities in technical and mechanical areas.
   - 2.4 To develop important mental characteristics such as critical perception, imagination, analytical ability, judgment, and self expression.
3. The cases are presented in a carefully planned sequence, each drawing upon knowledge and experience gained from previous cases.

   Quoting from a report prepared by Mr. Folts:

   > The early part of the subject is . . . organized in terms of techniques which are studied one after another. As soon as a technique is explored, management problems arising from the use of that technique are studied. Thus each early section of the subject deals with both technical and management considerations. As rapidly as student grasp of management concepts permits, the number of management problems in each section progressively increases. Delaying such topics as production control and manufacturing organization to (the latter part of the sequence) enables us to take advantage of the cumulative understanding of administration which the student gets from the (earlier) subjects.
   >
   > The organization of the subect can best be described by comparing it with an apprenticeship program. The new employee learns by doing —from the simple to the complex.

4. The presentation of Production material is by no means limited to student discussion of problems arising from the case.
   - 4.1 Extensive use is made of visual aids such as actual machine demonstrations, and especially prepared moving pictures.
   - 4.2 Although formal laboratory periods are not used, certain types of skills are developed by actual student participation in drills or exercises where physical facilities can be provided in the classroom. For example, even with classes which regularly contain 100 stu-

dents, each student is provided with a time study board and stop watch, and he gains some facility in making time studies by recording times for operations presented in the form of sound moving pictures.

4.3 Explanations of technical procedures frequently are made by the straight lecture method where appropriate. In fact, Mr. Folts indicated that perhaps one-third to one-half of the total class time was occupied by pictures, demonstrations, and lectures by the instructor.

From this brief discussion, it would appear that the more technical the subject in which the student has had no previous experience, the less adaptable will be the pure student-discussion type of case study, and the more will the instructor be required to present and explain basically new material.

Learning by Doing

The term "case method," which recently has acquired considerable publicity and popularity, implies "learning by doing." Intangible ideas and concepts, which can not easily be developed by physical demonstrations, are learned through the experience of personal participation in arguments and discussions. But the technique of "learning by doing" certainly is not new. Technical engineering laboratory courses are, in our opinion, live case courses in the real sense of the term. Perhaps one of the effective features of "case" courses is an increasing adaptation of the laboratory type of personal experience in subjects which, heretofore, have been considered too intangible for formal laboratory periods and physical laboratory facilities. It is to be noted that the philosophy of the case type of instruction is to induce the student to learn through personal experiences in practical problems which, for class room convenience, are closely simulated through well prepared cases.

Less Extensive but More Intensive Coverage

The case method often leaves the impatient instructor with a feeling that too much time is wasted on inconsequential discussions, and that insufficient material is being covered. But to the student who usually has much less knowledge or experience in the subject (often none whatever), such discussions may be significant and necessary steps in his grasp of the situation. At least they demonstrate that the student is alert and actively participating in the learning process, rather than merely sitting with a partially or completely closed mind while the instructor "covers a lot of ground" which no one by himself comprehends. Perhaps it is better to comprehend some material well, than to "slide over" a great deal of material without comprehension. If this proposition is accepted, then the instructor may be required critically to examine and evaluate his course outlines to assure that the truly important material will be included within the limitations of the time schedule.

Precautions

It may be in order to mention one or two precautions in the use of the case method. Inexperienced instructors often are inclined toward a too literal interpretation of undirected or free student discussion. One young instructor in a Human Relations course described some of his experiences. This instructor usually called on the first student to raise his hand in response to a question or to an argument presented by another student. It soon became evident that practically all the discussions were carried on by only a few members of the class. The other students avoided possible embarrassment by staying out of the arguments, but thereby lost the experience of active participation which the case method was supposed to encourage. One particularly eager student began to dominate the discussions. He always came to class well prepared and usually could argue down

any other students who did not agree with him. He emerged as the unofficial but nevertheless real leader of the course, with the instructor eventually becoming relegated to an unimportant role. The result was to stifle active participation by other students just as effectively as if the instructor had dominated the situation with his own opinions and preconceived solutions. Resentment grew among the other students to the point where they bitterly complained to the instructor and proposed some rather drastic actions against the overly eager student. Here was a real problem in human relations which developed unexpectedly and, by lack of appropriate early action, was permitted to grow out of control.

An older instructor with long experience in case studies later commented that the successful teacher of cases must know when it is proper to avoid completely uncontrolled student discussion, and how best to perform his function as a discussion leader by maintaining some reasonable balance of participation by members of the group.

We Believe We Can Use the Case Method

The current thinking in the Northwestern School of Commerce is toward wider use of the case method of instruction. We believe the basic philosophy is sound. Not all of us are yet convinced that completely free student discussion of problems with which they have no knowledge or experience, is the most effective way of developing or imparting technical information. At the undergraduate level, we are not yet sure that the average student has sufficient interest or maturity to seek information from outside sources in order to prepare adequately, and to project himself realistically into the completely unfamiliar role of a high level executive. We have much to learn in using the case method to the greatest advantage.

We are convinced, however, that any device is desirable that will arouse student interest and active participation, and we believe that the use of cases is one such device, perhaps one of the best yet developed. Many of us are of the opinion, however, that we already are using this device to a greater extent than would be admitted by some individuals who profess to be experts in this technique. Some persons seem to feel that a "case" requires many pages of descriptive material and must include a variety of problems and implications which may not be obvious without very thorough analysis.

What Is a Case?

It is our own opinion that a "case" presents a situation. It should require some discrimination to determine whether a problem exists, and what the problem actually is. It should challenge the student to plan a method of attack. This, in turn, should require an evaluation of available information, some decision as to what additional information, if any, may be required, and a plan for obtaining such additional information. The analysis should be followed to some logical conclusion. This conclusion should be evaluated critically to determine its acceptability and possible limitations, and a "plan of action" should be developed and evaluated for effective application. This description of a "case" and its use will be recognized as a systematic application of the "scientific method."

What Is a Problem?

In contrast to the case, a "problem" might be described as merely one phase of a case. A problem is assumed to have been already identified and actually to exist. Often it is presented without requiring any evaluation of its importance. Usually specific information is provided which the student more or less automatically substitutes into a prescribed procedure or formula, in order to "crank out" an answer which already has been predetermined by the instructor; and the student passively accepts the instructor's answer as the only correct or possible solution.

Perhaps the weaknesses in this "problem" approach are:

1. Original data are accepted by the student without question.
2. No discrimination is required to identify the problem and there is little or no evaluation of its practical importance or its relation to, or effect upon, other areas or activities.
3. The procedure or method of solution is prescribed, which the student is expected to memorize. There is no challenge to the student to develop a method of attack through his own ingenuity.
4. There is little or no evaluation of the accuracy, importance or completeness of the available information, or whether it is fact or opinion.
5. There is little or no evaluation of the reliability of the solution. The instructor's solution is accepted as the only correct or possible answer. Its applicability is unchallenged, and there is no incentive to consider limitations, alternate possibilities, or the means of application.

Can a Problem Become a Case?

It may be possible, however, to overcome most of these weaknesses, thereby turning a problem into a case, if the instructor exercises enough ingenuity in presentation. In our own courses in motion and time study, and particularly in the development of standard time data, the pass-out material would appear to the casual observer as problems rather than cases. However, each problem is introduced with a rather complete class discussion of its background, importance, and position in the Industrial Engineering function. The method of attack is developed through guided class discussion rather than by straight lecture. Practice in the use of the analytical procedure is obtained by working out the problem. On some problems, procedures are available whereby the student actually evaluates the accuracy and the applicability of his solution; and on other problems, the students' solutions are discussed in class to bring out possible implications and limitations in actual shop use.

This technique might be interpreted as a compromise between fractionalized presentations of individual topics through separate problems, and the more integrated approach through elaborate cases. If it is a compromise, we feel it is a convenient one for a technical subject. The problems have been developed for a well integrated course and are introduced in a carefully planned sequence so that each involves the use of techniques learned in previous problems. For this type of technical subject, we believe that we are achieving, in fact, about the same goals that are claimed for the "case" approach.

Grading

One of the problems in using case type courses is to find a suitable device for grading the progress of the students. Suitable quizzes are difficult to prepare. A popular type of examination is merely a written report on an additional case. Evaluation of such examinations is highly subjective and debatable.

Harvard's evaluations of student abilities are based on a novel and rather unique system. Six or eight quiz "cases" are written by each student during the school term. Each report is evaluated on an analysis sheet. Factors considered include: Selection of Facts, Use of Facts, Use of Figures, Development of a Decision, and Conclusion and Recommendations. Each of these factors is checked as Discriminating, Adequate, or Inadequate. The Presentation may be considered as Difficult to Understand, because of Handwriting, Expression, or Organization.

As these evaluation sheets accumulate, the ability of the student in any given area becomes evident. He then is interviewed by his instructor and together they attempt to re-direct the student's efforts so that the apparent weaknesses may be overcome. The success of this plan seems to be indicated by the trend from "Inadequate" to "Discriminating"

evaluations. No grades are assigned until the end of the course, and are based (apparently quite subjectively) largely on these evaluation sheets.

Report of Actual Experience

During the 1954 Fall quarter, we have used the Harvard cases, Production Volume I for our introductory production course, Industrial Management I. Approximately the first half of the quarter was devoted to blueprint reading and learning what operations can be performed on general purpose metal-working machines. Because these particular topics are somewhat uncommon in typical industrial management courses, available library references were rather inadequate in these areas. During the earlier sessions, the instructors attempted to develop the principles strictly from student discussion rather than giving any direct declaratory or factual instruction. This was a period of considerable frustration. The students had difficulty grasping this material and could not understand why a business manager should be concerned with such topics. The instructors felt that progress was discouragingly slow. To help overcome some of the difficulties, digests of certain technical material were prepared and passed out to the students, and the amount of direct instruction was increased.

During the latter part of the quarter, topics included methods improvement, time study, calculation of standard operation times, and wage incentives. Small assembly fixtures were constructed and made available to the students to use in developing improvements for their assigned problems. Stop watches were distributed for individual student use in time study practice. These physical facilities gave a much greater sense of realism. Furthermore the students were beginning to see some practical application of their knowledge of blueprints and machine operations. The general attitude changed from one of frustration to one of enthusiastic interest. One bit of evidence of this interest was a frequent comment by students that they were spending so much time on this course that they tended to neglect their other subjects.

Three different instructors were directly involved in the several sections of this course. Because the same material was being used, it seemed important that all sections should follow precisely the same schedule. Accordingly, the instructors visited each other's classes and spent a tremendous amount of time outside of class in coordinating their work. The instructors' burden proved much greater than usually is associated with a typical text-and-lecture type of course, but our present opinion is that the accomplishments are well worth this additional effort.

Need for Integration Between Fields

We have yet much to learn about the use of the case method of teaching, but we are sufficiently pleased with our results that we intend to develop its use to the best of our ability. It is our opinion, however, that the case approach in our Production courses will not reach its greatest effectiveness until a similar approach is used in the other areas such as Finance, Marketing, Statistics, Accounting, and Economics, and even then not until the courses in all these areas are closely integrated so the student can see the many inter-relationships in the composite picture of a business enterprise.

We are convinced the case method has many advantages for teaching business subjects, even those containing a considerable amount of entirely new and technical material. We believe also that, with sufficient ingenuity, a similar approach can be highly effective in many engineering subjects.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
PHIL WEINBERG, *Chairman*
University of Utah

LEE HARRISBERGER
Editor of YET-itudes
N. C. State College

Propagation YET

By LEE HARRISBERGER
Assistant Professor of Mechanical Engineering, North Carolina State College

The entire engineering teaching profession is dependent upon its new members for whatever progress it will achieve. The advances we must make in engineering education in the next 25 years will not be made by those who have been working hard the last 25 years—they will be made by the new teachers (the YETS) who are in our faculties right now!

The Committee on Young Engineering Teachers was appointed in 1949 to be concerned about the young teacher of engineering. The committee has appointed sub-chairmen to establish a local contact in each faculty of his section. Through these sub-chairmen and local contacts the CYET has established local groups of young teachers, organized programs for or about YETS at the section meetings and assisted the Society in its membership drives. On the national level the Committee has sponsored several excellent meetings at each national convention for young teachers. Since 1952 a National Paper contest has been established to encourage the young teacher to submit his ideas on improving engineering education. A great deal is left to be done for, about, and because of the young engineering teacher.

The industrial demand for graduates is at an all time high and will far exceed the supply for years to come. This particular demand for engineers today has attracted YETS to industry in droves. At the same time the suction of high industrial pay has cut heavily into the graduate school enrollment, the teaching profession's main source for YETS.

At the present time our undergraduate enrollment is low and the demand for new teachers is not great. This is fortunate since there are virtually no young men seeking engineering teaching jobs. Within a decade a tidal wave of war babies will be nearing our colleges and the enrollment will be doubled. The excellent publicity campaign by industry in the past three years has greatly increased this year's freshman and sophomore enrollments. Next year our engineering colleges will be hit with larger junior classes—the scramble will be on

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."

YET-itudes! Not Platitudes!

for new staff members—and there will be few to find. What are we doing to ensure that we will have adequate staff to handle this certain-to-come increase?

The time is about here when ways and means of recruiting young men into graduate work and engineering teaching must be found. We are faced with a real problem—we want to encourage our top seniors into this group. What can we offer?

For the student's immediate interest, we can offer him an assistantship or fellowship to go to graduate school (which hardly pays for his tuition and books and rarely covers his living expenses). We offer him 1–3 years of backbreaking studies and part-time teaching. We offer him an M.S. degree and hire him at the rank of instructor at a salary, in most cases, less than the salary he could have started with in industry with his B.S degree.

This is a tough row to hoe for the teaching profession. Perhaps we should persuade industry to help us perpetuate our race. Could we suggest that when an industry interviews our capable students, they select one or more of the students we suspect might make a fine teacher and sponsor him through graduate school at the same salary they would have hired him for? Industry admits that a graduate's first two years with them is mostly unproductive apprenticeship. Could we also suggest that upon his graduation, the sponsoring company let the man hire into an engineering faculty as a full time staff member and spend his summers doing research and engineering for them where feasible?

Industry can't function without the engineering talent we produce. We in engineering education can't produce this talent if industry attracts capable young men away from graduate work and teaching. The CYET is concerned about YETS—but it is equally concerned about having YETS to be concerned about.

Here is a YET-itude which cannot remain merely an attitude platitude.

The Engineering Graduate in Automotive Industry Today and Tomorrow*

By R. D. AMBERSON

Director of Personnel Activities, Chevrolet Engineering Department, General Motors Corp.

The engineer in the automotive industry today is no longer simply an engineer, whether or not he himself recognizes it. By the time his duties give him a right to the title of engineer, whether it be design engineer, project engineer or staff engineer, he has become an engineer-executive. Our aim today is to develop men effectively for their jobs and the jobs they will hold tomorrow. To do this we must be concerned not only with their technical competence, but also with their social adjustment and facility of expression. These last two are basic skills the engineer needs to be a successful administrator.

Today, industry values the ability to work harmoniously with others as highly as it does the technical competence of the average graduate engineer. Technical competence without social skills is insufficient. Friction can ruin a smooth running organization just as quickly as it can a well designed piece of machinery.

For this reason, Webster's definition of an engineer "one who is capable of designing" is no longer sufficient. Each new duty of the engineer has added a qualifier to the definition until Chevrolet can accept only this as adequate: "An engineer is one who is qualified by education, experience and ability, to direct the operations of personnel and facilities in the execution of assigned projects."

Quite a mouthful, but it must be, to encompass the usual duties of the average automotive engineer throughout his career.

To understand why we are so particularly concerned with these features of an engineer's duties you should know something about the organization of Chevrolet Engineering, and our method of dividing the engineering responsibilities.

The personnel of the Chevrolet Engineering Department now numbers about 1800. They are assigned to five functional groups, each of which is under the direction of an Assistant Chief Engineer. These groups are:

Research & Development Engineering
Design Engineering
Test Engineering
Production Engineering
Administration

The Research & Development Engineering group conducts studies and experiments leading to the development of new and advance vehicle designs to the point where they may be turned over to production design. The group is divided along natural lines between Passenger Cars and Trucks under the guidance of Staff Engineers.

Design Engineering is divided into four groups:

Passenger Car Chassis
Truck Chassis
Passenger Car Body
Truck Body

* Presented before the Cooperative Engineering Education Division of ASEE, University of Illinois, June 15, 1954.

Each is headed by a Staff Engineer who is responsible for the production design of the various components.

Test Engineering is conducted by two groups doing Technical testing at the Test Laboratory and Road Testing at the General Motors Proving Ground. These operations are assigned to a Staff Engineer.

The Production Engineering department has a number of men placed at the major plants who are known as Resident Engineers. It is their responsibility to maintain close contact between design engineering and the manufacturing organization so that the designs of all parts are suitable for Chevrolet's high volume production.

It is into this organization that we introduce graduate engineers and start them on our Training Program. In a two-year period we try to give the trainees a well rounded picture of our organization and its functions. This we accomplish by routing the trainees through varying assignments for periods of three months each, under the supervision of our Resident Engineers.

The Administration section provides operating facilities for the common use of the department as a whole, such as drafting, records and specifications, experimental fabrication and assembly, and interdepartmental liaison. It is also responsible for the interpretation and execution of the Corporation policies within the Engineering Department.

This entire staff reports to our Executive Assistant Chief Engineer.

This gives you some idea of the scope of administrative responsibility of the Chief Engineer and his assistants. While only about a sixth of these 1800 people are engineers, all of them are under the supervision of engineers.

Fail to Prepare for Broader Duties

Gradual extension of the engineer's influence and the multiplication of his duties has not yet, I think, struck the consciousness of the average undergraduate. He still seems to think in terms of a design job or a research project or some other short range objective, and consequently he often fails to prepare for broader duties he will inherit with the promotions he so intensely desires.

A recent survey by the National Society of Professional Engineers gives startling proof of the prevalence of this aspect of engineering. It concludes, "The complexities of modern industrial processes have tended to put more and more engineers into office jobs. Fifty-four per cent of the participating engineers work at desk jobs." 54%, think of that! That does not mean at a board or at a bench but at a desk job with administrative functions.

Another phase of engineering which may have escaped the notice of the average student is the fact that engineering has for some time been a coordinated activity. There are few positions anymore where the engineer can operate in seclusion. The majority of his assignments will be as a member of a group or a team, who contribute cooperatively to the solution of a product problem.

In industry as it is today, an engineer cannot do the whole job alone. For example, the engineer given the assignment of matching the chassis components for a comfortable riding automobile must depend upon the efforts of many other engineers. He must have the experience of the mechanical engineer to assist in the design of the chassis. He must call upon the metallurgical engineer when he is determining the type of spring material to be used. He must call upon another engineer who specializes in hydraulics when he is selecting a shock absorber. He also needs the services of the electrical engineer when working with the electronic instrumentation and when using strain gauges and oscilloscopes. In addition to all these, he must work closely with those engineers responsible for manufacturing and production activities. As you can see, the activities of people are just as highly integrated as production techniques.

Now, how are the engineers who are manning this organization measuring up to what industry expects of them? Evaluating their technical background, we would say "very well." Especially, those who have participated in a cooperative program while they were in college. We employ quite a few of these people at the present time. To be exact we have in our organization 62 graduates who had cooperative experience and we now have 38 people who are presently in the cooperative program. We have had ample opportunity to observe their performance and have seen that by the time they graduate, they are well acclimated to the industrial picture.

Of course we all know that education is much the same as heat treating. You must have something basically good to start with. You could heat treat a piece of 1010 metal from now on and fail to come up with the desired degree of hardness because the "stuff" was not there to start with.

The same applies to some graduates, very few, thank goodness, in engineering.

We also employ engineers who have graduated from the traditional four year course and have had no previous industrial experience. Let us compare the performance of both types of graduate.

We in Chevrolet feel that the cooperative student has the advantage over the solely academic graduate for the first ten years of his career. These are the reasons.

The cooperative student has had an opportunity to see the work that has to be done and to actually try many project assignments. Consequently, he is more likely to know what engineering work actually entails and to discover for himself what activity best suits his talents and tastes. He is, in short, less likely to leave a placement interviewer with the feeling that he believes there are only two major assemblies in an automobile—the engine and what goes with it. He is also aware that in an organization like Chevrolet, trucks are just as important as passenger cars in our overall effort.

In 1953, Chevrolet produced 343,000 trucks. More trucks than the entire individual output of two other G.M. car divisions. So trucks cannot be overlooked from an engineering standpoint.

Students other than cooperative with less experience in the actual work of engineering too often orient themselves towards the glamorized aspects of the field. Internal combustion engines for instance. They do not appear to appreciate the fact that the other major components—transmission, chassis, the suspension—are just as important as the engine. We cannot blame them for perhaps they have never looked at these other important features in the same light as they have seen the engine. We can be thankful that some of the sports car magazines, which sometimes come into the hands of engineers and students, also have made a point of emphasizing the effect that the design of the suspension has on the performance of these fast stepping cars.

Industrial experience sometimes tends to de-emphasize the importance of a diploma in the graduate's mind. He comes to the realization that it is what he has learned, not the proof of having spent years in school, that really counts. He will see that he has to take his place along side and compete with men who have just as much education as he has. His most sobering experience of all is, I think, meeting men who have never gone to college and who are very competent engineers. These are men who always possessed engineering talent but through lack of opportunity or the pressure of family responsibility have never had the privilege of attending college.

Opportunity to Learn and Grow

It is they who have accepted wholeheartedly what industry tries to offer every man, college graduate or not; that is, the opportunity for him to learn and to grow. These things the cooperative student has learned.

The cooperative student, after he has become acquainted with the work of engineering and has his feet on the ground, is more likely to have formed a definite opinion of where he is best suited and is better able to concentrate his effort toward that area in the field. In that he has selected a career objective, he has achieved a large advantage over the 4-year student, who at graduation has usually only a nebulous idea about his career objectives.

We have come to know that a cooperative system in a college is only as good as the coordinator, which is only another way of saying that you, as coordinators, are the keys to the whole situation. Our experience with one school, which I will not name, was bad. The coordinator seemed interested only in getting the student some kind of a job. Whether or not it related to what the boy was studying seemed to be secondary. After placing the student, he wanted no information as to his work record and declined to give out information to the employer regarding the boy's schooling.

In other words, the coordinator wasn't coordinating. This, happily, is the exception rather than the rule.

The attitude of most cooperative students is a pleasant contrast to the growing reluctance on the part of many graduates to accept work assignments which will give them the foundation and the experience they need to progress. Nowhere is this reluctance more visible than in the average graduate's attitude toward drafting room assignments. They look upon it with about as much relish as they would "the black hole of Calcutta." At the same time, none would refuse the opportunity to become a designer. You gentlemen realize, of course, that this is tantamount to a student requesting admission to a class in differential equations when he has no more than a superficial acquaintance with algebra.

You hear from the students that they don't want to get "stuck on the board" and yet it's the man with the sharp pencil who comes up with the design ideas and is preparing himself for an executive job in engineering. An executive without good board experience can be fooled by and good draftsman.

Think of Leonardo da Vinci, Thomas A. Edison or Michael Angelo. Those men were not above long hours on the board and in the laboratory and the results are known by all.

Drafting skill and experience are undeniable prerequisites to a successful career as a designer. As for the matter of opportunity, I don't know where students get their impression that there is any lack of it in the drafting room. The fact of the matter is that disinterest in drafting has created an unusual opportunity. Overconcentration of interest in testing, engine development and other phases of engineering has made them overcrowded and thus reduced, percentage-wise, the opportunities available through those avenues. The drafting room, on the other hand, has too few candidates for the positions which are available.

This presently creates an extraordinary opportunity for the gradute who is willing to be guided by his aptitudes, not his prejudices.

While colleges are turning out technically skilled engineers, many of them are unfortunately neglecting the development of executive potential.

The same survey I mentioned earlier, conducted by the National Society of Professional Engineers, reports that "sixty-two per cent of the employer group contacted felt that their engineer employees were inadequately prepared in college to meet the tasks which lay ahead of them in industry and, with this, twenty-eight per cent of the engineers themselves agreed."

The survey analysts further stated that "It was made quite clear that something should be done, and quickly, about the curriculum of many of our engineering schools . . . that engineers should be re-

quired to carry more English, and social studies and the 'humanities' . . . that, in short, those schools which have narrowed their curriculum to exclude or dismiss with a modicum of attention, nearly everything, apart from purely vocational work, had better start turning out more, not merely engineers, but educated engineers."

You can infer from this last statement that the dissatisfaction with the present engineering graduate is not because of his technical competence but because he lacks social skills and poise which are prerequisites to the more responsible positions in engineering.

These skills are not simply "icing on the cake." Industry, as you know, is not interested in the "polished" man for his own sake. These skills are in reality valuable tools which will enable him to perform his intended function. An insight into the gravity of the matter was given by a man in our group who was discussing the engineer's impatience at his lack of advancement.

He summed it up in this fashion, "Too frequently graduates are unable to realize that the next job ahead, while perhaps within the reach of their technical abilities, often requires, as well, abilities of another type—such as those required to direct and supervise others, to sell their ideas and plans—which they have not sufficiently demonstrated."

Invaluable Engineering Tools

Clear expression and persuasiveness are admittedly skills of rhetoric but they cannot be sloughed off with that admission. They are invaluable engineering tools. A short while ago, our Assistant Chief Engineer in charge of Administration called together all our engineers and reviewed the nature of their duties and responsibilities. He reminded the executives in charge of project assignments that "From his vantage point in the organization, the executive should know more about the overall situation than the operating engineers. He should make use of that knowledge in planning the execution of the project. But all the knowledge he may have and all the planning he may do is of little benefit until it has been clearly conveyed to the man who is responsible for getting the job done."

These skills must be displayed at lower levels too. "When the design has progressed to the proper point, it is the Project Engineer's responsibility to secure the necessary approvals. Here again he has the opportunity to show his true stature. If he makes a strong intelligent presentation, answering questions in a straightforward manner, he proves himself to be master of the situation. As such, he is merely giving a preview of how he is likely to operate on a higher level in handling broader assignments."

Equipping the engineer with these necessary social skills is the mutual concern of both industry and the educators. We at General Motors have made a beginning by providing our employees with opportunities to broaden themselves. The most popular and long-standing of these is our sponsorship of the Dale Carnegie course to develop effective expression—one of the primary tools of the engineer-executive. At this time, a large proportion of our men have participated in this course; and employee demand for the course continues.

We are planning now to exert even greater efforts through an Organizational Development Plan which was presented under the title "Safeguarding Our Assets," our greatest asset being good manpower. The object of this program is to develop our men along the lines we have just sketched. We have expended a considerable amount of time and effort to create an opportunity for the graduate to acquire the skills he needs for a successful career in engineering as it exists today.

At best we can only produce a patched-up job. We almost come to a point where it is easier to redesign than to modify any further. The best way to get the graduate industry wants is to start the fresh-

man on a program designed for modern requirements.

We feel that perhaps the solution to this problem will be in the path blazed by cooperative education, using a program to improve the social adjustment and facility of expression of the engineer, formulated by the colleges and carried out with the assistance and cooperation of industry.

Whatever the method; whether it be classroom work in Engineer's English, Social Sciences and the Humanities, as the survey suggested; more emphasis on group activity in academic work; or day-to-day insistence by the instructor that the student practice these skills; we have to cultivate them in order to prepare the engineer for his expanded duties of today and tomorrow.

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The Individual Manufacturing Operation—A Component of the Manufacturing Process*

By J. F. CLEARY

Instructor of Industrial Engineering, Case Institute of Technology

Within the framework of our theme, "The Function of the Industrial Engineer in Processing," I have been asked to discuss the relationship of the Industrial Engineer to the Manufacturing Processing Area and what can be done to raise the instructional level in this area. Before approaching the subject of how to present a more meaningful course coverage in Manufacturing Processing to the Industrial Engineering Undergraduate, I think it is necessary to review the premise upon which the suggestion is based. The function of the Industrial Engineer is gradually emerging from a quasi-managerial relationship to that of a clear-cut design function—the design of the manufacturing process. Upon the Industrial Engineer is being placed the responsibility of selecting the optimum operations for the work to be done, designing the tools that are required for the adaptation of the work to the equipment in question, and designing the pattern of motions used by the operator in performing the work. Finally, he is expected to integrate all the operations into a process that will produce the quantity of parts required to the quality specified, in the time required, for the least cost.

The objective of this design is twofold in nature:

(1) To optimize the probability of satisfying the consumer with respect to cost, quality, and the availability of the product.

(2) To insure the expected return on the stockholder's investment.

If this is an adequate criterion for the design of the process, then there is a serious question mark on the validity of our present approach towards one of the building blocks of the process—the individual manufacturing operation. It is not sufficient that the Industrial Engineer be able to analyze any particular operation for the purpose of developing an improved method, he must be able to survey all the existing operations capable of producing the part in question and to select the optimum operation.

Each part that is to be manufactured is a different problem. Each must be considered for the quantity required, the critical dimensions specified and for the delivery date indicated. A number of factors must be considered in each case:

(1) Should the raw material be brought into the process as some form of mill stock, a forging, or a casting?

(2) How can the total work required for converting the raw material to the finished part be subdivided into operations?

(3) Which of the alternative manufacturing operations are adapted to the type of work required?

(4) Are the natural dimensional variabilities of the suitable operations compatible with the design tolerances?

(5) Is it desirable, or necessary, to supply work and tool holding de-

* Presented before the Industrial Engineering Division, ASEE, at the University of Illinois, June, 1954.

vices for the operations under consideration?

(6) What is the nature of the procurement time for raw material and the tooling that is required?

These are typical of the factors, concerning the alternatives, that must be considered before the engineer is prepared to establish the process.

Anything But Static

The preparation of the Industrial Engineer for this design function could be started in the early Manufacturing Processes courses. I do not feel that learning the manipulation of the basic machinery and the associated terminology is sufficient. The status of the manufacturing operations is anything but static, new operations are in a continual state of development. It is, in fact, the engineer himself who is expected to do much of this development. The engineer must be armed, not only with a knowledge of the basic mechanics of the various classes of operations, but also, with the principles that determine when the operation is a competing alternative. While each of the classes of operations, such as metal-cutting, casting, forging, and etc. are governed by different fundamental principles, all the classes of operations are similar in that they are alternatives towards the objective of satisfying the consumer's product needs.

It may be that the consumer is not directly concerned whether the engineer uses a forging or a casting on a particular component of a product. He may not be interested in the fact that a gear is a precision casting, rather than a conventionally hobbed gear; but he is interested, to some degree, in the cost of the product, its availability for purchase and how long it will last in service. It is through these factors, and others, that the choice of the manufacturing alternatives may have a part to play in his decision to buy.

In developing the Manufacturing Processing courses to suit the Industrial Engineer's design requirements, the underlying principles of the different classes of operations must be emphasized to a greater extent. The design objective requires the ability to predict the outcome of the operation. This depends upon a more complete knowledge of the mechanics of the operations, rather than the ability to operate the equipment involved. The objectives of the Manufacturing Process work must be shifted from the development of manual skills to the study and application of the operation principles that are the foundation of the future design work.

There seems to be no good reason why the elementary courses cannot be approached from the current point of view, a course covering each of the basic classes. It does seem necessary, in each of the courses, to focus upon the philosophy that not only does each operation enter into competition with other members of its own class, but it may also, have to compete with operations of the other classes.

The elementary courses in Manufacturing Processes should develop two groups of principles:

(1) The principles governing the mechanics of the class of operation. For example, in the metal-cutting operations, the student should become familiar with current concepts concerning the mechanics of chip production. He should be able to estimate the power required by any of the metal-cutting operations. With the power available known, and a given tool life expected, the student should be able to specify the cutting conditions for most of the metal-cutting operations.

(2) The nature of the machinery in performing the basic operation. For example, the operation of turning a single diameter on a shaft can be accomplished by the use of a number of different types of lathes. The economic advantage of one of the machines over the rest, to a great extent, depends upon the number of pieces produced per set-up. If the shaft has several concentric diameters,

the relationship is somewhat different because certain types of the lathes are better adapted for the production of multiple diameter work. If the operation is a combination of external and internal turning, some of the types of machinery are all but useless. The student should be able to determine if the combined operation is more effective than the subdivision into two or more operations. This, again, will depend to a great extent on the number of pieces produced per set-up.

Exercise Projects

The supporting laboratory exercises could fall into three groups.

(1) A group of simple exercises where the objective would be to verify the operation principles, such as the effect of cutting speed, or material properties on the tool life.

(2) A group of simple exercises for which the objective is to compare the relative merits of the different machinery in producing a part. An example of this type of exercise would be the production of the simple shaft previously mentioned. The actual exercise could be conducted by a number of students, each making the shaft on a different machine, such as a turret lathe, an engine lathe, a duplicating lathe, an automatic lathe, and others if available. The laboratory report would be the joint effort of the students involved and would compare the different methods of producing the shaft for cost, dimensional and surface quality, and total production time. Other factors that could be examined in the report would be the effect on the relative merits of the alternatives of changing the lot size, of changing the type of raw material.

(3) A group of simple exercises where the objective is to demonstrate the method of determining the nature of the dimensional variability of the operations. This group of exercises would serve to demonstrate the relationship of the variability of the operation to the design tolerances.

The exercise projects could be selected such that they are applicable to more than one of the classes of operations. For example, if one of the exercises in the production of a gear, the gear could be designed such that it could be produced by machining, as well as, a punch press operation, or as a precision casting. In this manner, a greater degree of integration could be established across the Manufacturing Processes courses.

Besides the usual prerequisites, Physics, Metallurgy, Mathematics, and etc., it is felt that an elementary course in Statistical Methods would be very desirable for the successful study of the Manufacturing Processes. A large part of the problem in this area consists of estimation and determination of the superiority of one alternative over another. Both of these computations require the consideration of the variability of the data involved.

In conclusion may I say, I think it is necessary to make the courses in Manufacturing Processing of a more quantitative nature. This can be done by considering this as preparatory work for the design requirement of the course work in Production Engineering that is to follow.

Place of the Undergraduate Thesis in Engineering Education

By R. L. SANKS

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Introduction

Within the last decade, relatively little attention has been given to the subject of the undergraduate, or senior, thesis. During the same period, research, both industrial and academic has shown a steady growth and now constitutes one of the most important phases of engineering from the standpoint of manpower demands. Only a small minority of engineering students continue their training in graduate work, and therefore the only extensive contact with research that most graduate engineers will have experienced is with the senior thesis. It seems appropriate at this time to examine the thesis requirements to determine whether it is worthwhile and whether it is a necessary part of the undergraduate curriculum.

General Considerations

To determine the desirability and the place of the thesis in the undergraduate curriculum it is first necessary to state what we wish that curriculum to accomplish. It seems to the writer that its aims should be:

1. To develop initiative and resourcefulness in the student.
2. To teach the student to reason—to think—to use his head.
3. To train the student in independence —to learn without help—to work alone—to profit by his experiences.
4. To gain technical competence and understanding of theoretical and applied mechanics.
5. To impart a reasonable amount of technical information.

We try to accomplish these by lectures, laboratories, seminars, and infrequently by requiring a thesis. Whatever may be the advantages of the lecture, laboratory, and seminar (and even their most important advantages are somewhat questionable) it must be admitted that the students are carefully supervised, their study entirely prescribed, that the instructor is readily available to explain difficult subject matter, and that the "smart" student can get by with comparatively little effort by making use of his friends' industry. As a result, little initiative or creative thinking is required. The student need only read the required pages and work the required problems in the prescribed manner. And if he is confused, he need not reason out his difficulties; either his friends or his instructors will save him the trouble. Initiative, independence, and reasoning are not developed nor encouraged, although technology may be well covered by the ordinary curriculum.

Actually it would be possible to train the students' reasoning ability and independence in lecture courses, but it is impractical because: students vary so greatly in rate of comprehension that progress would be very slow; there seems to be an uncontrollable desire on the part of nearly all instructors (the writer included) to substitute volume for quality; and finally very, very few instructors are *able* to so train students. However, if handled even reasonably well, the thesis—or other difficult, comprehensive, nonsupervised laboratory course, which can be the equivalent of the thesis—will train students to depend on their own resources,

to reason, and to work alone. The process is analogous to throwing a small boy into deep water. The student learns these things because he must.

Advantages and Disadvantages

Some of our finest institutions have retained the thesis requirement, because the faculty recognized the advantages. For example, at Renselaer the thesis requirement was dropped during wartime but reinstated soon after. Hunter [1] of Renselaer stated that the thesis is desirable because:

1. It synthesizes material studied in numerous courses.
2. It bridges the gap between college and practice.
3. It provides the stimulus for average students to do superior work.
4. There is enough effort required of each student for instructors to judge his capabilities.
5. The thesis acts as a final test of his interest.
6. It brings students into closer contact with instructors.
7. It forces him to plan his work.
8. It forces him to use all the facilities of the college and frequently to use those of industry.
9. It gives him practice in the preparation of the formal report.

Michaels [2] stated that the undergraduate thesis requirements in Chemical Engineering at M.I.T. were dropped during World War II but reinstated in order to give the student an opportunity to:

1. Make decisions on a problem of some significance.
2. Gain experience in seeking information.
3. Discipline himself in budgeting time and facilities.
4. Integrate study with prior experience.
5. Gain experience in writing a formal report.
6. Meet the staff on a professional level.
7. Develop creative talents.

To codify the advantages according to their importance, the writer would list them as follows:

1. It requires the exercise of initiative and resourcefulness.
2. It trains the student to reason and to work alone.
3. It provides his only opportunity to select, plan, execute, and report on a problem of his own choosing in a field of his major interest.
4. It provides an opportunity to survey thoroughly a limited field of literature.
5. It furnishes a small host of minor advantages such as:
   a. Correlation and integration of student's career.
   b. Appreciation of research and research methods.
   c. The starting point, sometimes of a student's life work.

Of course there are disadvantages too, and they should be carefully examined.

1. The thesis requires an inordinate amount of time for the few credit hours nominally assigned.
2. There is comparatively little gain in technical proficiency for the large expenditure of student time.
3. Much time is required of instructors, particularly during the editing of the manuscript.
4. The wide variation in difficulty of problem and instructor's requirements makes the thesis unfair to some and too easy for others. This leads to a general lowering of standards and encouragement of poor theses.
5. It is difficult to select or advise problems within student's capabilities compatible with credit hours and

[1] Hunter, M. A., The Senior Thesis in the Undergraduate Curr., J. Eng. Educ. 37: 453–486, 1946–7.

[2] Michaels, A. S., The Undergraduate Thesis in Chemical Engineering at M.I.T., J. Eng. Educ. 43: 90–94, 1952–3.

difficulties equal to or comparable with problems in other areas of engineering.

Most of the above disadvantages are those of inconvenience to the staff, the students, or both, and the writer fears that those departments that have dropped the thesis requirements have done so largely because of inconvenience to the staff. Certainly we should be more concerned with education than with a misguided sense of "fair play" for the student or inconvenience for the instructor. Some of the disadvantages can be overcome by proper administration.

Administration

Ideally, the key thought should be as little interference, as little direction, as possible consistent with reasonable progress. However, the student must be supervised to the extent that he becomes indoctrinated with the research method and with enthusiasm for research. He must not be allowed to make so many mistakes that he flounders helplessly and eventually, hopelessly. Practically, then, some supervision is desirable; but never to the extent that it robs the student of his one chance to use his own initiative.

During the first quarter, the student should receive some guidance in the selection of a suitable problem, in the use of the library, and in the planning of the thesis. He needs a certain amount of pushing to overcome his inertia. During the other quarters, the student should meet regularly with his advisor. An excellent way to maintain supervision unobtrusively is for the advisor to hold weekly seminars for all his thesis students. Each student can then report his progress, which keeps his feet from dragging, brings the advisor up to date, and creates a stimulating atmosphere of lively interest in research. Handled correctly, the students become the critics and the advisor usually need act only as referee. This permits the advisor to keep the whip in his hand without seeming to do so.

It was stated that one of the objections to the thesis was inconsistency of instructor's requirements. This is most marked in the preparation of the manuscript. One of the best arrangements to promote uniformly good theses is found at Iowa State College. There, format and arrangement, references and bibliography, title page, table of contents, sample figures, sample pages, and typing are carefully checked by the permanent library staff. The standards are the same for all departments. This practice results in nearly uniform high quality thesis manuscripts. Other schools would do well to emulate this example.

Another common defect of the thesis is the amount of work required per credit hour. Certainly it seems unrealistic to require any considerable original effort of a student during the time he is carrying a 17-hour credit load of other subjects. Since the thesis trains students in the most important and desirable of accomplishments, the sensible curriculum would allow enough credit hours for the thesis so that excessive interference from other courses is avoided. During the first quarter, while the student is selecting his topic, one credit hour is probably justified, but during the two successive quarters at least three and perhaps even four credit hours should be assigned to the thesis. (For schools on the semester system, 2 and 3 credit hours for the first and second semesters respectively should be assigned.)

Types of Theses

The type of thesis has considerable bearing on the value the student receives from it. The library thesis—an extensive search, evaluation, and conclusions drawn solely from study of the literature—is advantageous in that a great deal of information may be gained in a short time. On the other hand, the undergraduate is not usually well-equipped to evaluate the worth and importance of a technical paper. The library thesis requires somewhat less planning and considerably less initiative than other types.

The design thesis is appealing to many, perhaps because of the magic of the word "design," or perhaps because there is a definite goal within easy sight of the ordinary student. Although it might seem at first thought to be a desirable type, there are several serious practical defects: an impressive thesis can be compiled with little work and no acquisition of new knowledge; there is frequently a lack of challenge to best efforts; and most important, the technical training of practical design considerations and procedure is usually lacking entirely, since the textbooks do not consider them and the instructor cannot give the time necessary to teach them. Practical design is best left for industrial experience; in fact it must be because it requires several years experience for even outstanding students to become proficient designers.

The experimental thesis may consist of laboratory experiments, field experiments or surveys, or theoretical explorations of some phenomenon, supported by investigation of the literature. Such theses involve extensive planning, interpretation of results, and correlation of findings to theories. It represents the closest approach to the work of the consulting engineer. More than any other type it provides the greatest challenge to clear thinking, initiative, and resourcefulness. Its only drawbacks are that it may be time-consuming and there is not always the assurance of ultimate success. Of course, an unsuccessful thesis that has taxed the student to the utmost— that has developed in him the qualities we wish to teach—is of more value than the successful thesis of ordinary difficulty.

Summary and Conclusions

The foregoing is an attempt to evaluate as objectively as possible, the advantages and disadvantages of the requirement of the senior thesis. Assuming reasonably good administration, the disadvantages are those largely of inconvenience to the staff —an inadmissible excuse. On the other hand, the advantages include training and development in important disciplines that are inadequately touched by other formal courses. The advantages are, therefore, so overwhelming that it might well be said that the faculty that does not require the senior thesis or its academic equivalent is shortchanging the student.

The Engineer as an Expert Witness*

By S. S. AIDLIN, P.E.

There are occasions when an engineer is called into court to testify as an expert witness relative to a phase of engineering with which he is quite familiar. Frequently, the engineer educator is the man who is called upon because of his knowledge and/or reputation.

Generally, the occasion is one involving a law suit with considerable sums of money in the balance and the legal decision largely dependent upon the information furnished by the professional engineer.

Who May Testify as an Expert Witness

Others who are not duly licensed professional engineers may possibly be brought into the picture to serve as expert witnesses relative to specific issues. But recent court rulings have apparently given greater credence to the testimony of the professional engineer just as the license of the medical doctor carries greater weight in issues involving medical questions. This is based on the recognized principle that the licensed practitioner is bound not only by well-formulated Canons of Ethics, but by an extensive examination of his ability in the art and practice of his profession. Thus he is qualified on two counts, his ability and his moral standards. In addition there is the implied understanding that his professional conduct is subject to review by the same licensing board that granted the license and that it may be revoked in cases where his conduct is detrimental to the profession or otherwise unworthy of the license.

The author of this article has appeared in court a number of times as an expert witness and the following comments and observations are largely based on personal findings and considerations.

Qualifications of an Expert Witness

When the professional engineer does appear in court, his qualifications are usually not challenged by the opposition. However it is wise to state one's qualifications in order to impress the court and jury. Qualifications are sometimes challenged on the following grounds:

A. If one is a specialist, his field may be too narrow to encompass the immediate issue.

B. If one is not a specialist, his field is too broad to know enough about the specific issue.

C. If one is old, he may not be conversant with the latest developments and advances in the profession.

D. If one is young, he may lack adequate experience to qualify.

Method of Testifying

It seems best, therefore, to present one's knowledge in the subject. Generally speaking, a witness can be cross-examined only on what has come upon direct examination. Therefore, it is advisable to adhere to simple facts, stated in generally understood terms rather than in highly technical language. The latter may be misunderstood, or worse, its

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* From *Professional Engineering—Economics and Practice*, originally published in 1952, by Pelex Publishers, Inc., New York, N. Y.

Mr. Aidlin is a consulting engineer with offices in New York City and is on the teaching staff of two leading Engineering Institutions.

meaning may be distorted by the opposition.

To give a specific example, in a recent court case wherein the author was testifying, the question was whether there was attempted fraud on the part of a contractor in selling and installing a central heating furnace and boiler which were inadequate for the building where installed. A heat balance was made and it developed that a vendor's proposal (which became part of the subsequent contract) was for a properly rated boiler. However, the unit installed bore no name plate data nor any recognizable professional rating. Tests indicated that the unit could not get up enough steam to provide adequate radiation for comfort heating and the contractor contended that the piping was at fault (which was not included in the contract).

In another instance there was a contention raised that a device used on amusement vehicles such as roller coasters for holding passengers in the compartments infringed on another patented device for automatic locking of compartments. The author of this article was called as an expert witness by the defendant and was able to show that the roller coaster locking mechanism functioned on the same principle as ordinary toggle clamps in general use in machine shops everywhere, except that the actuation of the clamping mechanism was controlled from outside the compartment. Thus, by presenting the explanation on the basis of common experience, it was possible to show the lay jury that there was no infringement in this case.

In the presentation of the engineering witness's findings, he did not refer to equivalent square feet of radiation, BTU's heat transfer coefficients, etc. Instead, it was pointed out in simple language that the boiler lacked adequate volume for proper firing of the required oil for suitable heating of the premises, that the boiler surfaces exposed to the heat of the fire were inadequate for development of the required amount of steam. The evidence offered was personal observation and opinion basd upon previous experience, comparison with accepted well known rated boilers and recognized trade and professional standards. (The verdict handed down was as we expected.)

Frequently, the opposition will attempt to trip up the professional engineer testifying by attempting to lead him into an argument. The witness should adhere to the facts without losing control of the situation by arguing. The lawyers generally win out in such instances.

In addition, when asked if the engineer has made a complete examination or analysis there is an attempt made to confuse the witness because a complete investigation is virtually impossible. Instead, a proper answer should be that the investigated was as extensive as warranted.

Printed Matter as Evidence

Inasmuch as writings, as such, are not subject to cross-examination, they are generally not admissible as evidence.

However, such material may be considered as corroborative evidence and may be introduced in such a manner. But it may be introduced by the opposition in an effort to becloud the issue or to cast doubt on the evidence of the engineer. Before doing so, the opposition may introduce the writing and ask if the witness (the engineer) considers the author of the writing as an authority. There are several possible answers that may be offered by the witness:

1. May not consider the author an authority.

2. May explain that the writings are out of date and that the beliefs or opinions outlined therein are superseded by more advanced ideas in the profession.

3. May consider the author an authority in certain respects only. This prepares an opening in the event of a subsequent disagreement between the author and the witness.

In any event, it is wise for the witness to prepare himself with reliable writings

by others or his own which have been sponsored by or published by recognized authoritative groups such as professional or engineering societies. However, it is best not to cite these writings until the opposition has introduced others, because this affords an opportunity to refute contrary opinion.

Fees Charged by Expert Witness

In the matter of fees, the opposition will attempt to influence the jury and to cast doubt upon the evidence of the witness on the basis of personal interest in the outcome of the case. Accordingly it is unwise and, in fact, unethical to accept a fee contingent upon the outcome of a case.

It is generally advisable to charge on a time basis depending on the amount of time involved. This usually includes an allowance for travelling time to and from the court. It is well to bear in mind that the fee basis should be made in advance to those who will be expected to pay the bill, and agreed to by them. However, in some instances, because of excessive or intolerable demands, the expert witness has been subpoenaed to testify without fee.

Subsequent Courtroom Action

In connection with the above, it is recommended that the witness leave the courtroom as soon as he has presented testimony. He should not wait around lest he be considered an interested party in the case, and lest he be discredited for having no practice to occupy his time. However, by leaving directly, the jury will consider that the witness is willing to stand on his testimony. By the same token, one should not read or whisper in court, but should comport himself in a dignified manner so as to reflect dignity upon himself and upon the court.

Another bit of advice: The witness should not assume he knows it all nor give that impression. The opposition is probably prepared to a large extent and may, in fact, have been briefed before coming to court. The lawyer may unsuspectingly lead the cross-examination into muddy waters for the witness, leading him to contradict or correct himself. This is detrimental to the impression he wants to establish.

Summary

In this brief article, it has not been possible to record all of the important considerations for an expert witness preparing to enter court for the purpose of presenting his testimony and/or evidence. However, several salient factors have been brought out:

1. Do not argue with the attorney.
2. Comport one's self with dignity.
3. Establish an air of authority and qualification for the presentation of the testimony.
4. Present the testimony in a clearly understood manner on a layman's level.

With these thoughts in mind, the engineer should have no difficulty in creating a favorable impression.

Some Findings About Visual Aids in Engineering Education

By ROLAND W. PINGER

Lecturer in Mechanical Engineering at Univ. of California at Berkeley, Colonel (Ordnance) U. S. Army, Retired

As a teacher of engineering passes middle age, he encounters an old dilemma. Should he continue his search for new facts to be added to the world's knowledge, or should he check, analyze, interpret, and publish those which he has already found? He could, of course, do all of these things, but in this paper I shall emphasize the last two only. For this task I am aware of a semantic limitation applying to many older writers—the fact that younger men have re-discovered old ideas and given them new, precise and polysyllabic names. The oldsters have heard most of these specific terms, and have profound respect for them. Unfortunately age does not improve the memory, so I ask my readers' indulgence when I use only simple engineering English to express some of my *findings* about visual aids in engineering education.

Many Languages

In my teaching, military and academic, and even in the education of my descendants I have been impressed by the great difference between human beings, in the reception and transmission of ideas. Men wishing to influence their fellows therefore appeal to the eye as well as to the ear, and in appropriate cases, to the nose, palate or finger-tips. Moreover, having selected one sense, say the aural, they modify their approach according to the desired objective—to entertain, instruct, persuade, or induce, as the case may be.

It is not strange, therefore, that men have developed *many* "languages," of which, for us, oral and written English are the most important. Judging from the speeches and essays of my students in "Professional Aspects of Engineering," these are also the most neglected in the pre-college training of our embryo engineers.

Music is another of these twin languages. The vibratory form is not easily expressed in words, but it is interesting to note that the *written* version has come down through the centuries as a kind of graphical Esperanto, based on what are really Cartesian coordinates. Mathematics is still another language, and we are forever indebted to the Arabs for delivering us from the clumsy Roman notation which might have imprisoned our numerical souls.

In the transmission of *certain* ideas, however, none of these languages suffice. Crude murals in the caves of Spain described the bison better than a thousand words from Confucius, had he then been born. In fact, had the sage copied the pictures in his own day, his simplified duplicate might have become the official Chinese character, or *ideograph*, for the unfamiliar bovine.

Pictorial representations take myriad forms—sketches, drawings, paintings, graphs, figures, diagrams, to mention only a few. Limiting our discussion according to purpose and desired response, we must leave to others the languages of amusement, esthetics, forensics, advertising, and the like, and concentrate on *instruction*. We must show objectively

how to transmit knowledge of *all* kinds, and subjectively how a student may learn to distinguish between the true and the false.

Some Findings

So we come belatedly to *some findings* about visual aids in engineering education. Subject to later elaboration the most important are as follows:

a. In the teaching of certain concepts with a minimum of ambiguity or error, words often must be supplemented, or even replaced, by visual aids.

b. In developing visual aids at the collegiate level, little help may be expected from existing educational sources. The latter are usually related to lower school levels, involving different purposes and responses.

c. Likewise, little help may be expected from existing commercial sources. Even the vendors of "overhead" projectors find collegiate demand insignificant as compared to that of lower schools and business enterprises. There is doubtless more money in selling ready-made films, strips, and slides the year around, than in selling a projector once in a generation.

d. Unless the collegiate teacher has time, patience, and skill, or commands the services of a talented assistant, he had better adhere to his chalk and blackboard, which cannot be excelled for many purposes. On the other hand, even if worthless as a *learner's* aid, a visual device may serve a useful purpose in clarifying the teacher's mind as no mere words and numbers will do.

e. The objective of any visual aid should be to provide a broader and more accurate mental conception of the matter otherwise presented—not merely to "sugar-coat" it. Such real understanding is indispensable if the student is to develop engineering judgment, and the intuitive ability to accept truth and reject error.

f. Finally, and most important of all, visual aids can be quite deceptive as to effect. After spending hours in their design and fabrication, the teacher may find that, from the student's viewpoint, they "go in one eye and out the other." My own belief is that in the engineering field, unless a *copy* of the aid is provided for home study, the aid is seldom worth showing.

Amplification of Findings

The "engineering method" does not encourage the stating of conclusions before the pertinent facts and analysis thereof. In any event it insists upon an *array* of the latter, no matter what the arrangement may be. This requirement, however, is incompatible with present space limits. So, in the light of many years of experience in the use of visual aids in both military and academic atmospheres, I shall merely amplify my lettered findings. You will observe that these overlap, or are related to each other.

Finding *a* (basic need for visual aids) is not very original. Our engineering textbooks are full of tables, graphs, diagrams and figures each of which is expensive from the publisher's viewpoint, but presumably worth the cost. These are all learner's aids. If the instructor wishes to use them as *teacher's* aids, or to expand that use, he may have to develop dozens of his own. Under these circumstances my preference is to *face* my students with a modern "overhead" projector, and with an efficient modern screen, which can be used instantly without darkening the room, or interfering with ventilation or note-taking. With a little experience these devices become as casual as the traditional chalk and blackboard. "Slides" will be discussed later.

In connection with *b* (help from educational sources) I should like to mention two exceptions. First, the educational services of the Armed Forces are apparently far ahead of the universities in the matter of high-level visual aids. One explanation is financial; another is a disbelief in the Mark Hopkins–log tradition,

according to which Mark did not even need chalk and blackboard.

As a second exception I must mention "A Graphic Approach to Economics" by K. William and Lore L. Kapp (Henry Holt and Company of New York, 1951) and particularly its preface, which should be read by everyone interested in graphic methods. This book, of course, is a learner's aid. If I were using it, I should convert much of it into "slides."

Item *c* (help from commercial sources) was a great surprise, when my Alma Mater eventually bought me a $200 "overhead" projector. The manufacturer's literature implied that making "slides" was a very simple thing. Actually it took more than a year's research to find a *black ink* that met my specifications for use on cellulose acetate. Like Edison in his search for rubber, I tried almost everything, but finally evolved a simple solution—ordinary clear lacquer dyed with "Speedry" or equivalent transparent black or colored ink. One salesman, accustomed to the well-financed operations of the advertising business, suggested that I simply turn my problem over to my "art department"; he was amazed to find that I was *it*.

On the other hand, the same gentleman suggested the "ozalid" and related photographic processes, which are probably more practicable for those who dislike using colored lacquer in a ruling pen. My ultimate techniques in the *design, production and use of large slides* (to which I am still adding) may be material for a sequel to this paper; in the meantime I offer free consultation service. "How to Prepare Transparencies for the Vu-Graph Projector," published by the Charles Beseler Company in April 1953, is useful but not complete.

It was also something of a surprise to find that commercial magazines devoted to audio-visual matters should contain so few articles on "overhead" projection and transparencies therefor. Mr. James C. Beaver's "Music Overhead" in the March 1954 number of *Educational Screen*, however, may indicate a change in trend.

The technological difficulties of *b* and *c* have their ideological counterparts in *d* and *e* (toil and objective). I have discovered that a vague paragraph is easy to write, but can be quite difficult to translate into explicit graphical form. Assumptions must be made, constants replaced by variables, and unmentioned alternatives introduced. The result is often highly informative, and even more fundamental in its implications than was contemplated by the original author. Nevertheless, much time is required, and one must balance that factor against other commitments. Perhaps the best method is to suggest the problem to one's students, and *let them work out the details*, thus converting a teacher's aid into a learner's aid.

As to *f* (effectiveness) I learned thirty years ago that projecting an idea into the eye of a student did not necessarily file it in his brain. Teaching ordnance engineering to upper-classmen, I used four or five hundred old-fashioned $3\frac{1}{4}'' \times 4''$ lantern slides. I took the precaution, however, to get one of our arsenals to supply each student with a set of blueprints from the related negatives. Although small, these prints and accompanying mimeographs "recalled" my lectures at will. Middle-aged men (colonels and lieutenant colonels in World War II) still flatter me with favorable memory of this unusual procedure.

Teaching "Engineering Economy" since my retirement from the Army, I have encountered the same problem with 400 modern $8'' \times 10''$ slides of my own design and manufacture. Up to now I have found no duplicating process quite cheap enough, but I still have hope. In the meantime I believe that in comparing students who have *not* been exposed to visual aids with those who *have* (but who have received no copies for home use), little difference in assimilation will be found. This may be disappointing to

visual aid enthusiasts, but I fear that it is true, at least in engineering education.

Conclusion

In conclusion I believe that we are only on the threshold of education through the eye. Until an organized "grammar" of visual presentation is evolved, we must work by trial and error, and without being too easily discouraged. We must constantly test our methods by measuring our results. Finally, we must learn to discard unprofitable techniques, no matter how much love and labor we have bestowed upon them.

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Discussion of "Engineering Education Across the Country"

By D. L. TRAUTMAN

Department of Engineering, University of California, Los Angeles

Many interesting responses have been received relative to the above paper in the November 1954 issue of the *Journal*. In the words of one, "I found it stimulating and to the point. I would be pleased to hear about other reactions to it—particularly by engineering teachers." It appears appropriate to report the reactions of those who responded to this and to an advance distribution of the paper last spring; the several dozen replies came from a cross-section of engineering staff from Dean to Instructor. The body of this present note thus consists of representative portions of these comments in continuous context.

"An excellent and concise report which should stir up a lot of constructive thinking. Perhaps my mental outlook is not as old as might be considered from the length of time I have been teaching, but I find myself in almost complete agreement with not only your observations but also your suggestions.

"Your article is of particular interest to me. My assignment at the present time is to make a study of Engineering Education. . . . It has been my personal observation that the situation throughout the country is very much as you described it. I had an opportunity to visit about thirty engineering colleges last year and gained a very depressing impression.

"I was very glad to receive your letter and article in Paris. I must admit, however, that your findings and my observations in the few weeks that we have been back in this country have been somewhat discouraging. Many of the criticisms which you make are remarkably close to those I made of various schools abroad.

"Unfortunately engineering education in other countries is also reasonably close to your outline. In some cases the aim is even less laudatory than the preparation of students for entrance into a career. It sometimes degenerates into something which approaches a degree factory. This is doubly unfortunate in some of the countries concerned since such an enormous number of problems remain to be solved in them that methodology and decision-making are apt to be much more important than mere factual knowledge.

"It has also been my observation that it is not common to find the combination of aggressive leadership and staff. I am sorry to note that it does not appear in the U. S. on a large scale either.

"I found myself irritated by feeling that the paper supported a preconceived thesis instead of reporting objective observations.

"Such phrases as 'essential essence of engineering education' are difficult to interpret. What essence of engineering is not essential? What do you mean by a fact? If a fact is defined as anything which is true, what is the difference between a fact and a concept, or is a concept which is not a fact of any value? How can anyone get an understanding of concepts or ideas or of disciplines except through facts?

"'Training for routine doing'—depends upon implications of the word routine. (*a*) If we prepare students to handle varied engineering assignments in a 'rou-

tine manner,' that is, by employing a scientific approach whenever necessary, and solving by application of the proper fundamentals—then we are accomplishing something. (*b*) If, however, it is the *problems* that are routine, and the students are unable to solve any others, then we are not even one step above technical training.

"'No concerted attention is given the gifted student'—I believe our most urgent present problem is to concentrate first on raising the general level of our engineering education—then worry about taking the gifted student even further. It appears to me that the essence of Engineering is 'systems' in the broadest sense. However, after the perusals I have made of various engineering school catalogs I am of your opinion that the undergraduate program is almost devoid of any systems or synthesis work.

"I do not see that the primary emphasis on lectures is necessarily bad. This presumes, of course, some student preparation prior to the lecture and that the lecture is not merely a reading from a textbook but an extension or emphasis of interesting topics. Some of the discussion necessary for straightening out ideas in the student's mind ought to come while working assigned problems. If these problems are of more than merely routine nature, their correction can serve as a very nice feed-back mechanism to keep the lecturer informed as to the progress of the class. (This, of course, assumes a reasonably sized class.)

"My own opinion would be that integration on the basis of method is of more use than that on the basis of content.

"It really would be quite valuable to have a summary of what trends actually are. You do half of this job in the part of your paper listing tendencies toward change. I should be equally interested in the other half of the picture, listing tendencies toward remaining unchanged. It would be quite valuable to have a report of your observations telling what changes are being made and what changes are not being made.

"I believe we have attempted to remove many of the factors which you have indicated hamper a vigorous evolution of engineering education, principally by giving our younger members of the faculty broad latitude in arranging their programs.

"For several years we have given a comprehensive examination as part of the requirement for the first engineering degree which, in our five-year program, happens to be the Master of Science degree. In part 4 (j) of your paper you mention a senior comprehensive in engineering. We are engaged in a re-evaluation of our comprehensive examination requirement and are interested in learning of the experience of other institutions.

"Too many courses everywhere have 'grown' into the supervised study class of operation,—the product being learners instead of creative individuals.

"The ideas you have gathered from your study are stimulating and helpful. However, I gain the impression that we need to be sure we have our feet on the ground and are not carried away by pedagogical balloons.

"Your observations seem uniformly critical, except toward experimental procedures. While, admittedly, overemphasis of deficiencies may be necessary to obtain approval for a change, a proposal for a new approach is greatly weakened in the minds of realistic and thoughtful teachers if it does not point out the strong, as well as the weak, points of the system it is to replace.

"It certainly makes clear that we have a long way to go to make education really effective. As a matter of fact this kind of challenge has been one of the things that makes education attractive to me as a field to work in."

Candid Comments

Thermodynamics for Chemical Engineers

By F. M. TILLER

Dean of Engineering, Lamar State College of Technology

In an article published in the November, 1954 issue of the *Journal,* Professor A. B. Cambel proposed the teaching of a well-integrated series of courses in thermodynamics, fluid mechanics, fluid flow, and allied courses. Very aptly he suggested that the solution to improving inadequate subject material did not consist in simply adding more advanced courses. Too often engineering teachers burden the curriculum with new material rather than solve the basic problem of teaching a student thoroughly at the first opportunity. While repetition is excellent and necessary if planned properly, it is not infrequently boring and wasteful of precious time. The proposals of Professor Cambel would help solve some of our problems involving repetition and integration.

While Professor Cambel has recommended a five semester sequence, it is my opinion that the special problems of a chemical engineer require more time. Fluid flow, heat transfer, and the introduction to thermodynamics are virtually the same for all engineers; but beyond these courses, the chemical engineer must be further trained in Gibbsian thermodynamics, phase rule, kinetics, and many of the topics included under the heading of physical chemistry. In designing a new curriculum in chemical engineering at Lamar Tech, a program was initiated which is based on much of the same philosophy discussed by Professor Cambel. Basically the sequence of courses is as follows:

1. Introduction during sophomore year
   a. First semester: material balances, vapor pressure, latent heat, ideal and non-ideal gases, critical phenomena
   b. Second semester: first law of thermodynamics, thermochemistry, fuels and combustion, phase equilibria, Raoult's law, Henry's law
2. Thermodynamics during junior year
   a. First semester: first and second law, vapor cycles, heat engines
   b. Second semester: properties of non-ideal substances, Maxwell relations, Gibbs and maximum work functions, physical equilibria, chemical equilibria
3. Allied courses during junior year
   a. First semester: fluid mechanics
   b. Second semester: heat transmission
4. Senior courses
   a. First semester: third law of thermodynamics, kinetics of chemical reactions
   b. Second semester: kinetic theory, spectroscopy, colloids, statistical mechanics

In addition, a junior course in modern or solid-state physics is required. The order of subject material is somewhat different from that suggested by Professor Cambel but generally covers the same area.

With respect to laboratory work, I would disagree with Professor Cambel in having lecture and laboratory run concurrently. It seems preferable to plan the

lab course to follow the lectures by at least one semester. When the two are given during the same semester, it is difficult to schedule experiments so that classroom theory is always synchronized with laboratory needs. When laboratory instruction follows classroom work, a desirable repetition and review is effected.

The position of the traditional course in physical chemistry as based upon Daniel's textbook presented a knotty problem. The chemical engineering department was of the general opinion that the repetition of the first and second laws between physical chemistry and thermodynamics was unnecessary and that the usual physical chemistry treatment was too cursory. As an experiment, the first semester of physical chemistry was dropped, and chemical engineering students went directly into the second semester. While this plan was successful, expansion of the sophomore course and introduction of advanced physics made the overlap with physical chemistry too extensive, and it was temporarily dropped from the program. In following the development of sophomore chemical engineering courses throughout the country, I have come to the opinion that educators should carefully scrutinize the present physical chemistry course in relation to what is being taught in other courses. Where the introductory course in chemical engineering has been expanded and chemical engineering thermodynamics is included, the physical chemistry course should either be eliminated or modified.

Teaching Tips

Construction of a Demonstration Slide Rule

By WILLIAM K. VIERTEL

Instructor, State University Agricultural and Technical Institute, Canton, N. Y.

The design and construction of a demonstration slide rule might under some circumstances make a good student project. Making the calculations teaches something about logarithms, and organizing and carrying out the job of computation has an educational value. Putting logarithms to a directly useful purpose such as this provides powerful motivation.

The writer has found it possible to construct such a rule, 8 feet long overall with scales 2 meters long, which can be seen from the back of a fair-sized classroom and which works smoothly. It was made using only tools and materials which are easily available, with no skilled labor except for making the slides and grooves. This article is to record some of the details of the construction for the benefit of any others who might wish to build such a rule. Since factory-made rules like this can be bought for $25 to 30, the project is not recommended as a means of saving money. Its worth, if any, lies in the educational value to those who do the work.

The writer built this rule unaided except for the making of slides and grooves, which was done by a skilled workman using power tools. The rest of the work took the equivalent of about two to three weeks of full-time effort, and the result was a rule with the following scales: A, B, C, D, CI, DI, CF, DF, CIF, K, L, LL3, S, T, and ST—in other words, the equivalent of the Keuffel & Esser "Polyphase Duplex Decitrig" or the Pickett & Eckel "Ortho-phase," model 1000, plus one log-log scale. Other log-log scales could have been added, but were not needed in our situation.

The most difficult part of the job might be to get seasoned lumber. The writer was fortunate in being able to find some salvaged boards which were dry and straight and which, when planed, nail-holes and knot-holes filled with plastic wood, shellacked, and painted with two coats of flat white, made a fairly good appearance. Two boards, $\frac{3}{4}'' \times 6'' \times 8$ ft. were used. One of them made the slide; the other was cut in half lengthwise for the two pieces of the body, which were $\frac{3}{4}'' \times 2\frac{3}{4}'' \times 8$ ft.

The slide was grooved on both edges, and the two pieces of the body were grooved on one edge with power tools, to make a tight fit on smooth splines $\frac{3}{8}'' \times \frac{3}{4}'' \times 8$ ft. The splines were glued to the slide to make tongues on each edge, and then the tongues and the grooves in the body pieces were sandpapered until a smooth sliding fit was obtained.

The end-pieces which held the two halves of the body together were made of $\frac{1}{4}''$ plywood cut to resemble those on an actual rule and painted with aluminum paint. Six $\frac{1}{4}'' \times 1\frac{1}{4}''$ bolts and washers held the assembly together, using extra washers to provide space between the end-pieces and the slide so that it would not rub.

Calculations for the scales were made all at one time and arranged for easy reference. To lay out the scales, the division marks were first located with a sharp nail and a meter stick. They were then drawn in with a ruling pen and

black drawing ink. It was necessary to protect the lines from rubbing until one side of the rule was finished, when it was given a coat of clear varnish.

The numbers, letters, and other markings were put on the rule using rubber-base paint which comes in tubes having a ball point,* making it very easy to apply and fast-drying.

For the indicator "glasses," two pieces of clear transparent plastic 1/8" and 7" wide were used. (The other dimension would depend on the overall width of the particular rule—in this case, 13".) The "hairlines" were put on the inside surface of the indicator "glasses" using the same rubber-base paint that was used to apply the numerals.

It is recommended that the boards for the two pieces of the body should be 4" wide instead of 2¾" if four more log-log scales are to be added to the rule here described.

The writer would be glad to furnish further details to anyone who is interested.

* Available from Tri Chem Inc., 82 Main St., W. Orange, N. J., in 1- and 2-oz. tubes costing 75¢ and $1 respectively. Many colors available, including red and black.

ANNUAL MEETING

June 20-24, 1955

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The following rules were adopted by the General Council of the ASEE:

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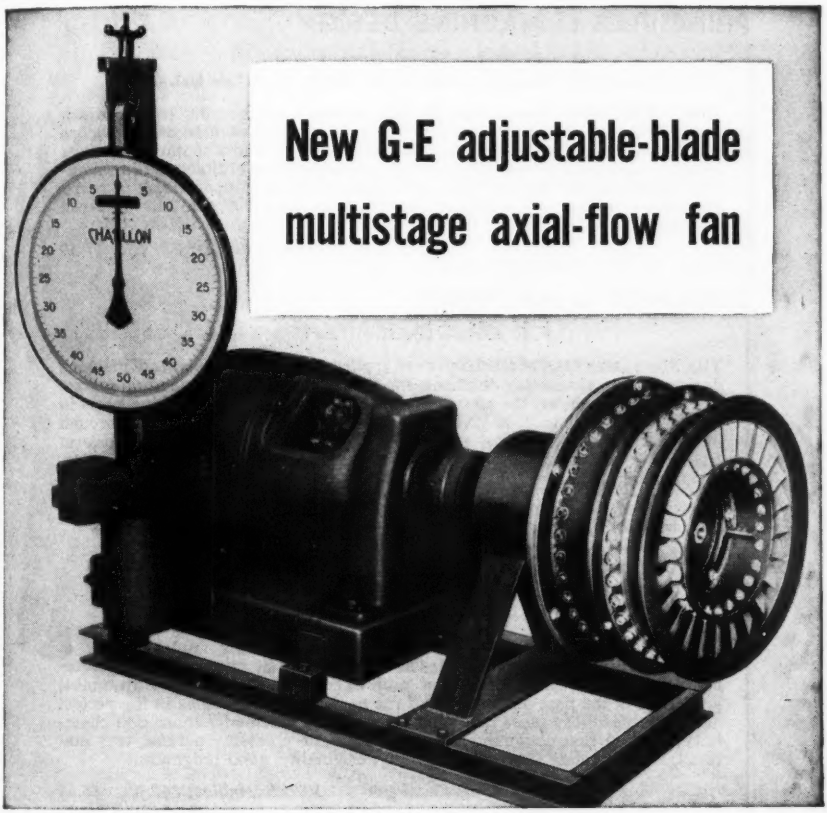
Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings



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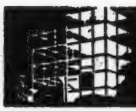

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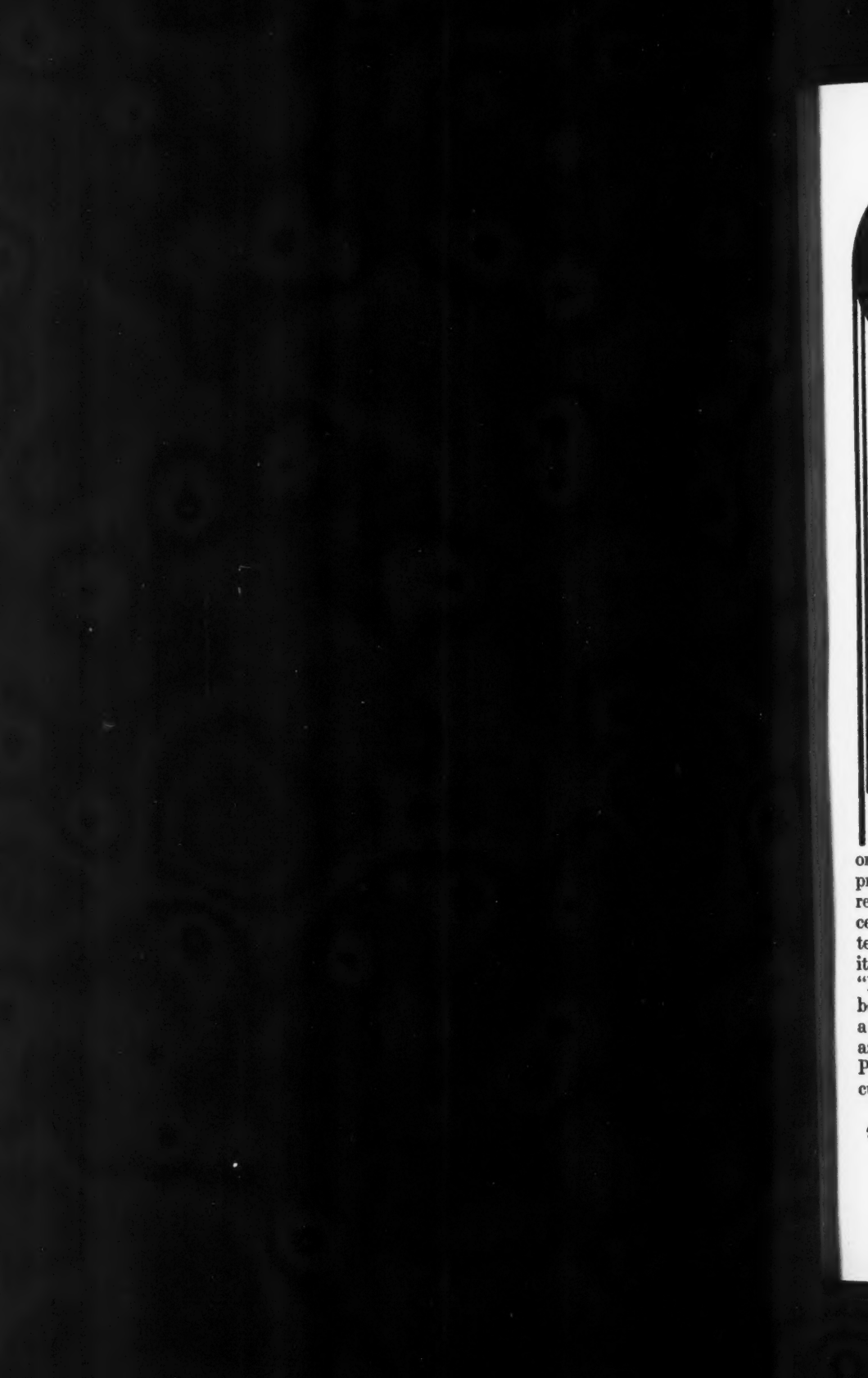

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